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ATARNotes

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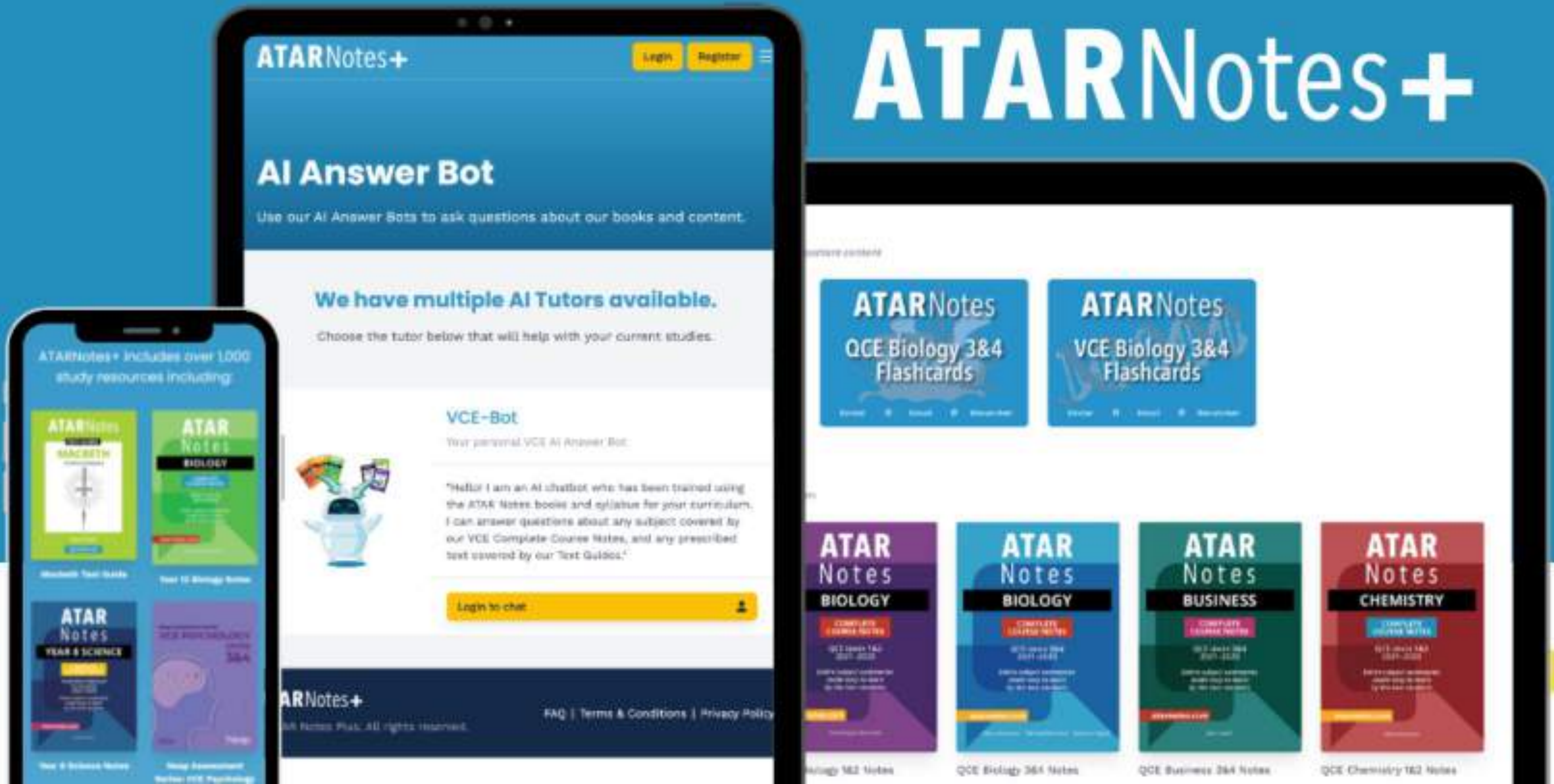


ATARNotes

Physics Unit 3&4 HEAD START LECTURE

January

OVERVIEW

Topics to be covered

- Aim of the day
- Things you need to know from Unit 1/2
- Motion
- Fields
- Electricity Generation
- Tips for succeeding in year 12 and unit 3/4 Physics

Announcements

- Slido for MCQ
- A 15 min break for Q&A

Aim

- Today’s goal: give a brief overview of some of the topics encountered in unit 3
- We don’t have time to go through ***every detail***
- Get a headstart on the concepts today focus on the detail when you learn it throughout the year

THINGS TO KNOW FROM UNIT 1/2

- General guide to answering questions
- Newton's 3 laws
- Constant acceleration formulae
- How to do vector addition
- Momentum and Impulse
- The concept of work
- Gravitational, spring and kinetic energy

Calculation answers:

- **ALWAYS WRITE THE FORMULA YOU ARE USING**
- Then substitute the numbers in
- Solve for your answer

$$a = \frac{v^2}{r}$$

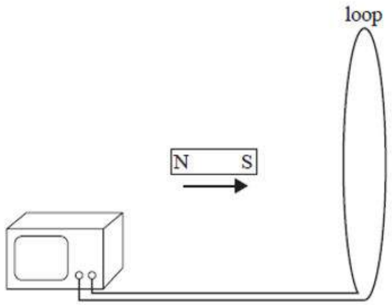
$$= \frac{(7.7 \times 10^3)^2}{(6760 \times 10^3)}$$

$$= 8.8 \ m s^{-2}$$

HOW TO ANSWER QUESTIONS IN PHYSICS

Worded answers:

- Always put it in **dot points – be concise**
- General structure – this may vary depending on the question
  1. Explain the **theory** related to the question
  2. Put the theory in **context** to the question
  3. Final statement if necessary



a. Explain why an emf is generated in the wire loop as the magnet approaches the loop

- Faraday's law states that if there is a change in magnetic flux, emf will be generated as $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$
- As $\Phi_B = BA$, if magnetic field strength changes, the flux will change
- Hence, as the magnet gets closer to the loop, the magnetic field strength increases changing the flux and generating emf.

REVIEW: NEWTON'S 3 LAWS

- Take a moment to think about whether or not you know these laws off by heart

Newton's 3 Laws:

1. An object will remain at rest/travel with a constant velocity if the net force acting on the object is zero.
2. The acceleration of an object is directly proportional to the force applied, and inversely proportional to the mass of the object. ($\Sigma F = ma$)
3. If object A exerts a force on object B, object B will exert an equal and opposite force on object A
   ($F_{A\ on\ B} = -F_{B\ on\ A}$)
   note that these forces act on different objects

REVIEW: CONSTANT ACCELERATION

- These formulae are on the end of year formula sheet
- Remember the variables:
  - s (or x) – displacement (m)
  - u – initial velocity (ms^{-1})
  - v – final velocity (ms^{-1})
  - a – acceleration (ms^{-2})
  - t – time (s)

$$v = u + at$$

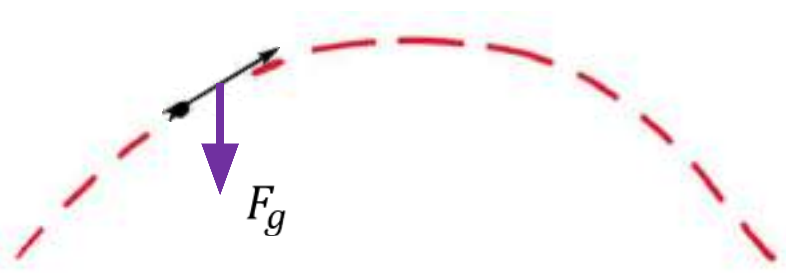
$$s = ut + \frac{1}{2}at^2$$

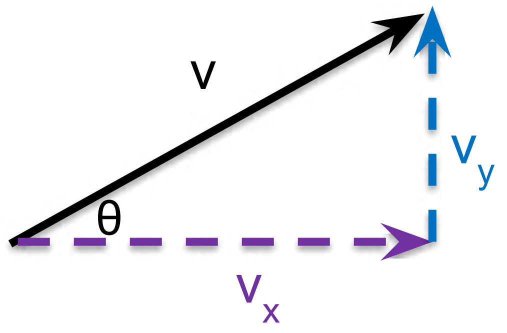
$$s = vt - \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

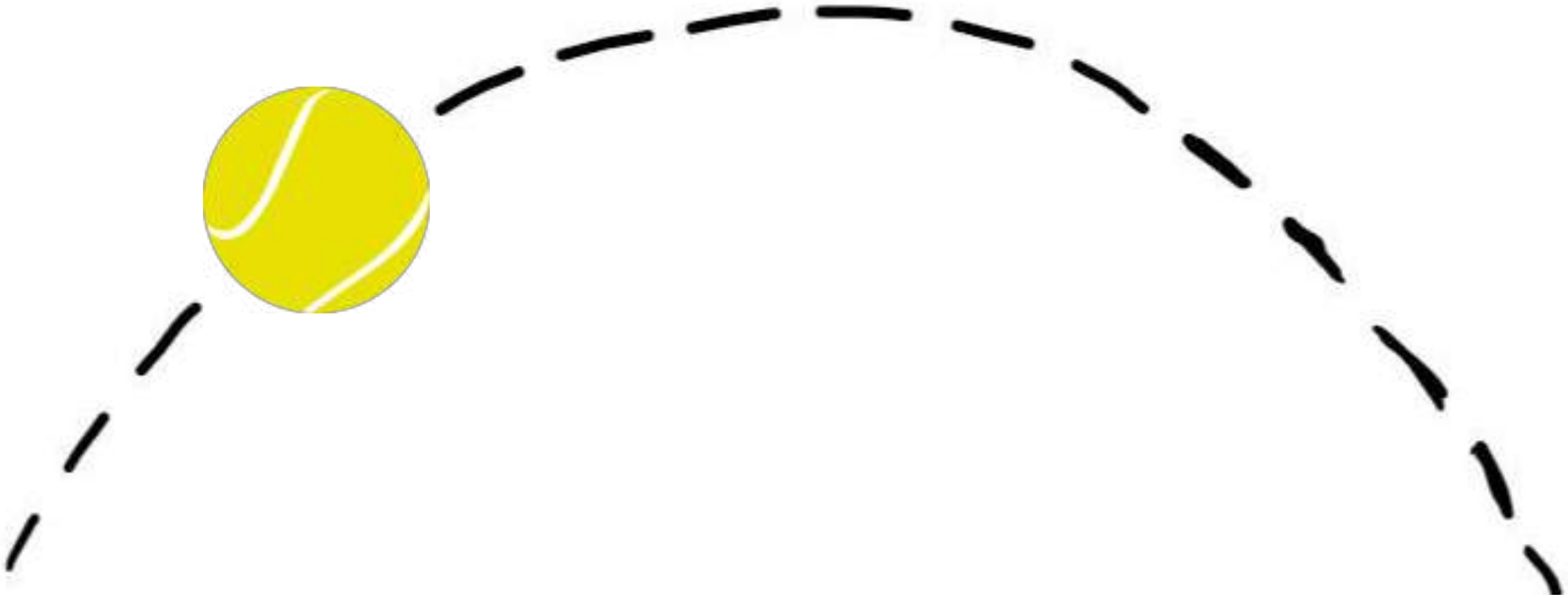
$$s = \frac{1}{2}(v+u)t$$

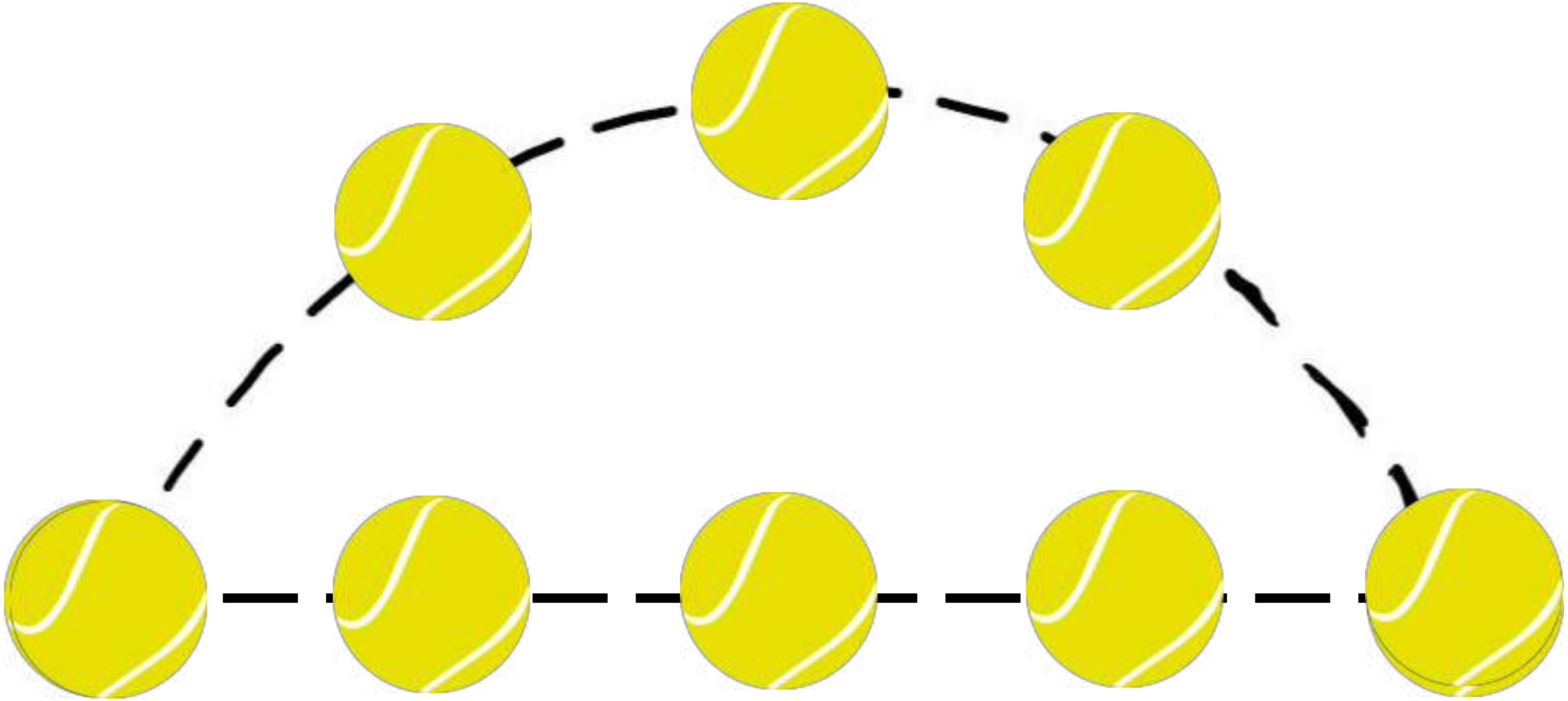
- **Projectile motion** is looking at motion in 2D
- Remember that velocity is a vector and can be split into its components due to vector addition
- There are two components that can be treated individually:
  - A horizontal component
  - A vertical component
- They can be found from v using trig
- **IMPORTANT:** the only force acting on this object in projectile motion is gravity





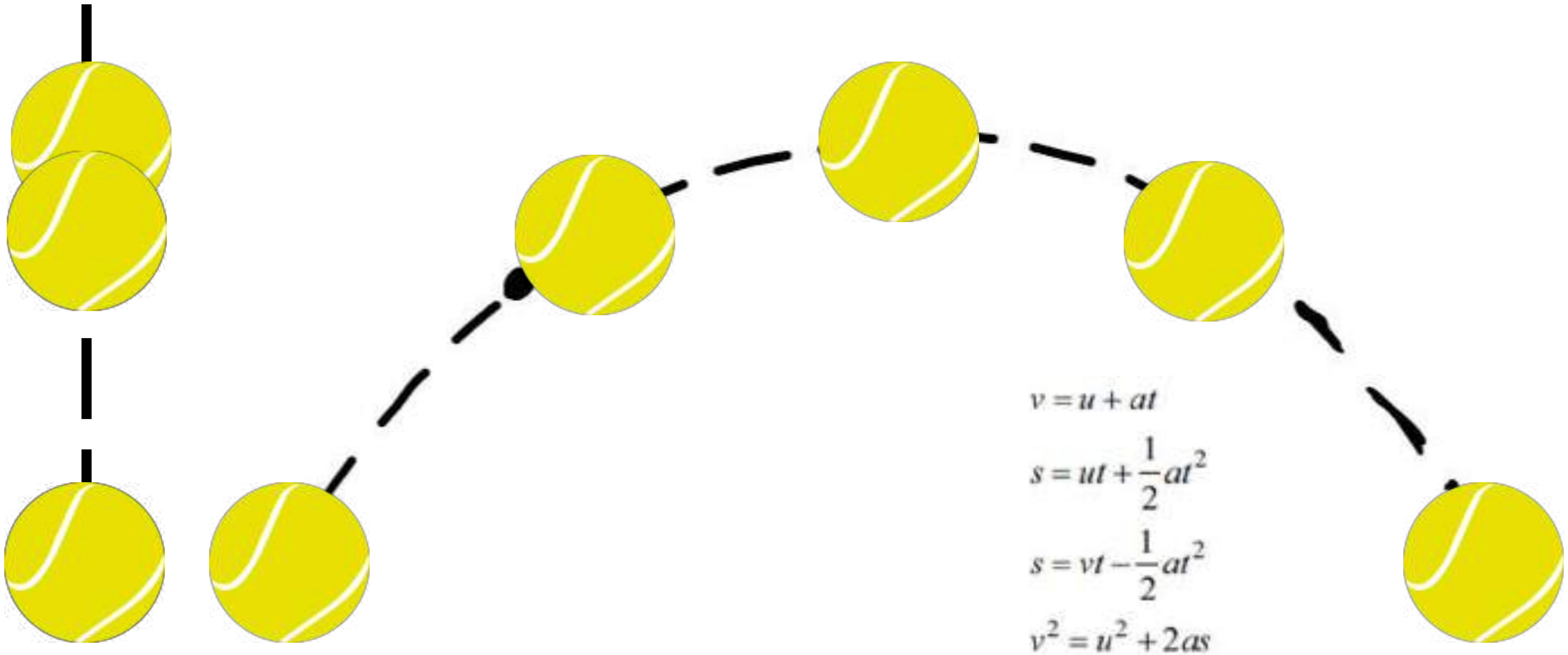
PROJECTILE MOTION





The horizontal velocity remains constant because there is no horizontal force acting on the ball

PROJECTILE MOTION



$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$s = vt - \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \frac{1}{2}(v+u)t$$

The vertical velocity is affected by gravity, causing it to accelerate in the vertical axis

PROJECTILE MOTION

Key points of projectile motion where the object is in the air and under the influence of gravity:

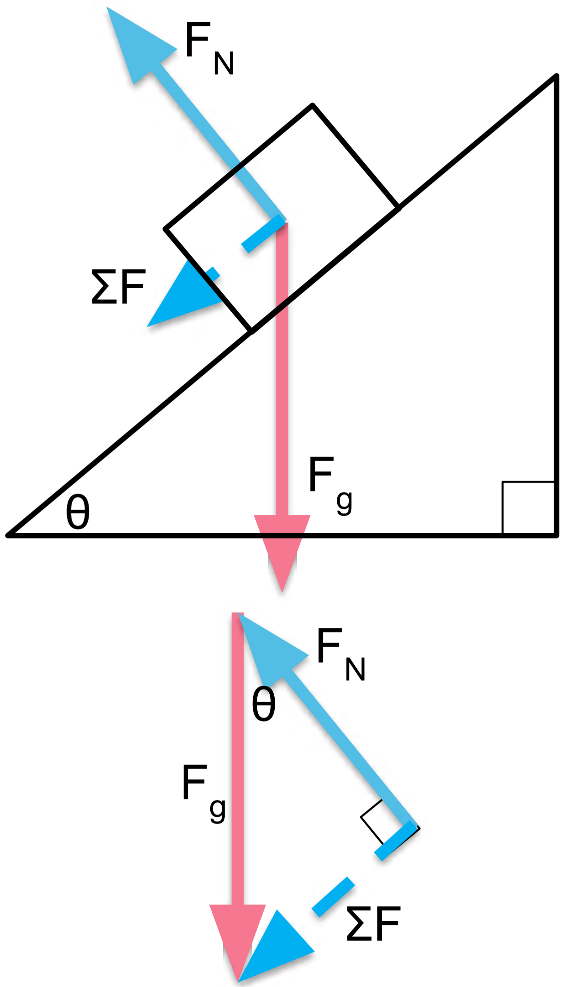
- The only force acting on the projectile/object is **gravity** (excluding air resistance)
- The horizontal and vertical velocities are **independent** of each other
- The **horizontal velocity** is **constant** $v = \frac{x}{t}$ or $x = vt$
- The **vertical velocity** changes due to **gravity** – but the acceleration is constant (a = (-)9.8 ms^{-2} on the surface of the Earth)
  - Hence any of the constant acceleration formulae are applicable

REVIEW: FORCES

- Remember: forces are vectors and vectors can be added
- When dealing with forces, we use a lot of vector addition and Newton's second law
- We will review
  - Inclined planes
  - Tension

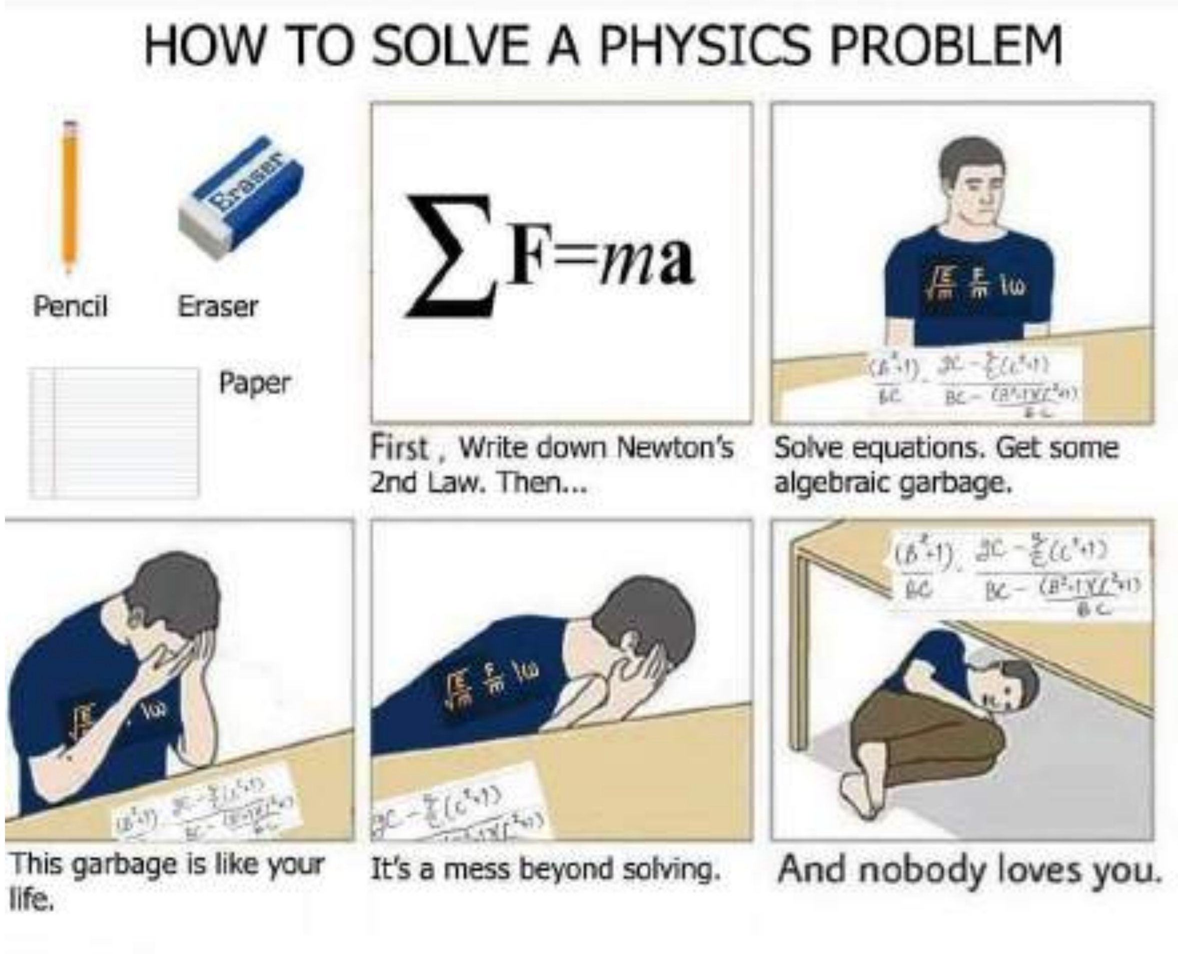
REVIEW: FORCES – INCLINED PLANES

- Two forces act on an object on an inclined plane (excluding friction)
  - The weight force
  - The normal force (always perpendicular to the surface)
- These forces give a net force that acts down the plane
- These forces can rearranged to make a triangle to find out other information about the object using trigonometry



REVIEW: FORCES - TENSION

- Tension is the force in a rope/object that is created when something pulls on it
- Many people struggle with tension questions
- Questions asked in physics are often interested in the **magnitude** of the tension
- The best way to illustrate this is through an example



TENSION TIPS

- **ALWAYS ALWAYS ALWAYS DRAW A FORCE DIAGRAM**
- Find the **acceleration** of the entire system – look at the system as a **whole**
- Once you have the acceleration, use **Newton's second law** to find the tension – look at an **individual** component

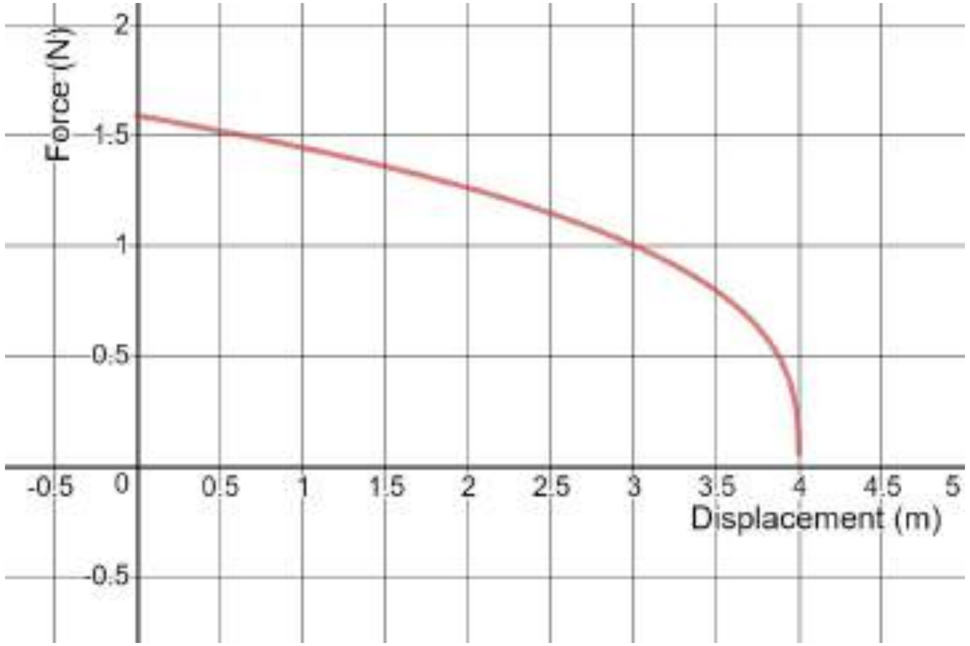
- This works most of the time so if you're stuck, give it a go!
- Also be very careful with **signs and directions**

REVIEW: ENERGY AND WORK

- **Energy** is the ability of an object to move
- There are three types of energy
  - Gravitational potential energy: $U_g = mgh$
  - Kinetic energy: $E_k = \frac{1}{2}mv^2$
  - Spring energy: $U_s = \frac{1}{2}kx^2$
- Variables:
  - m = mass (kg)
  - g = gravitational field strength (N kg^{-1})
  - h = height (m)
  - v = velocity (m s^{-1})
  - k = spring constant (N m^{-1})
  - x = extension/compression (m)
- **Law of conservation of energy**: for an isolated system, the total amount of energy is conserved but it can be transferred or transformed

REVIEW: ENERGY AND WORK

- **Work** is defined as the change in energy of an object
- $W = \Delta E = Fx$
  - W = work (J)
  - F = force (N)
  - x = displacement (m)
- Work can also be defined as the area under a force distance graph when the force acting on an object is not constant



Work done for 3 m of displacement:

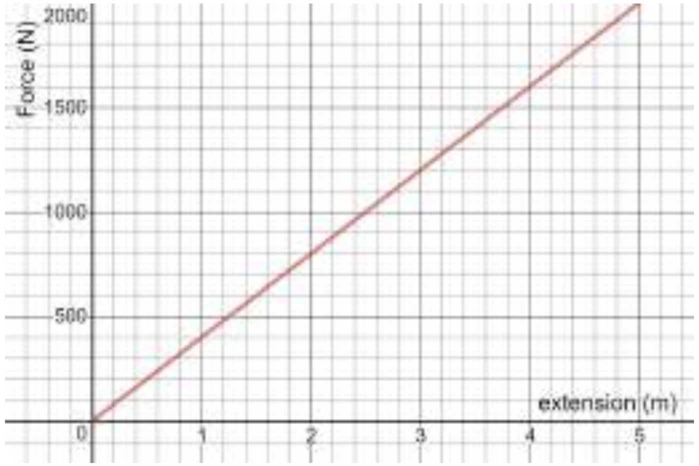
$W = area\ under\ the\ graph$

$(W = no.of\ squares\ \times area\ of\ one\ square)$

$W = 16\ \times (0.5\ \times 0.5)$

$W = 4\ J$

- One of the worst done topics on the exam
- It comes up pretty much every year
- Today, we will focus on an **oscillating spring** where the spring is hung from the ceiling and there is a mass attached to it
- Two perspectives when looking at springs:
  - **Force**
    - **Hooke's Law** where $F = -kx$
    - Note that k is the gradient of a force-distance graph of a spring
  - **Energy**
    - All three types: U_g, U_s and E_k



OSCILLATING SPRINGS

- Let's discuss what happens in a spring at 3 different points of its oscillation in terms of energy and forces

$$U_g = mgh$$

$$E_k = \frac{1}{2}mv^2$$

$$U_s = \frac{1}{2}kx^2$$

Top:

- Energy
  - U_g = maximum (equals total)
  - E_k = 0 J
  - U_s = 0 J
- Forces
  - F_g = constant
  - F_s = 0 N

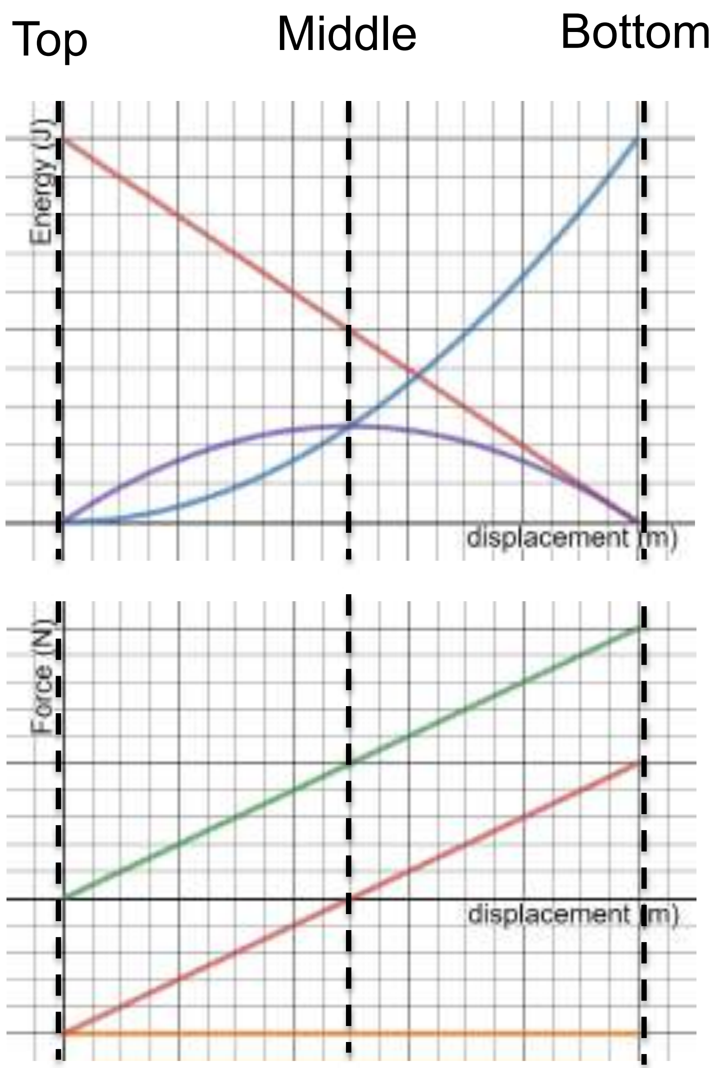
Middle:

- Energy
  - U_g = half total
  - E_k = maximum
  - U_s = somewhere in the middle (makes up the rest of the total)
- Forces
  - F_g = constant
  - $F_s = F_g$

Bottom:

- Energy
  - U_g = 0 J
  - E_k = 0 J
  - U_s = maximum (equals total)
- Forces
  - F_g = constant
  - F_s = maximum

OSCILLATING SPRINGS



Energy/displacement graph:

- Red = gravitational energy ($U_g = mgh$)
- Blue = spring energy ($U_s = \frac{1}{2}kx^2$)

Connected between net force and kinetic energy
Net force = 0 N □ no acceleration □ maximum velocity □ maximum kinetic energy

Force/displacement graph:

- Orange = weight force
- Green = spring force ($F = -kx$)
- Red = net force

REVIEW: MOMENTUM

- **Momentum** is $p = mv$
  - p is momentum (kg m s^{-1})
  - m is mass (kg)
  - v is velocity (m s^{-1})
- Momentum can loosely be thought of how hard it is to make an object stop – never write this down but it's a nice way to think about it
- **Law of conservation of momentum:** momentum in a collision is always conserved

REVIEW: IMPULSE

- Impulse is a measure of the change in momentum of an object when a force acts on it
  - $I = m\Delta v = F\Delta t$
    - I is impulse acting on an object (kg m s^{-1} or Ns)
    - m is the mass of the object (kg)
    - Δv is the change in velocity (ms^{-1}) = $v_{final} - v_{initial}$
    - F is the force (N)
    - Δt is how long the collision lasts for (s)
- Due to **the law of conservation of momentum**, the **magnitude** of the **impulse** acting on one object is **equal** to the magnitude of the impulse acting on the other object in a collision – they just act in **opposite directions**

REVIEW: IMPULSE

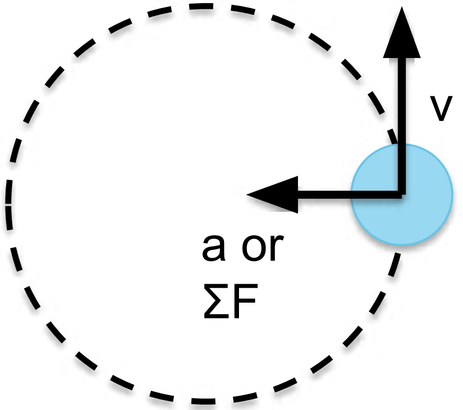
- $I = m\Delta v = F\Delta t$
- Something cool to note about this equation:
  - If you catch an egg, you've applied an impulse on the egg by making it stop
  - For a given mass and change in velocity, the impulse is constant
  - If you increase the time of the collision, the force acting on the egg decreases, making it less likely to break
  - This can be done by moving your hands as you catch the egg

ELASTIC AND INELASTIC COLLISIONS

- In a collision, **momentum is always conserved**
- Kinetic energy is not always conserved
  - It can be converted into heat, sound or deformation of the objects
- There are two types of collisions
  - **Elastic collisions** – collisions where kinetic energy is conserved
  - **Inelastic collisions** – collisions where kinetic energy is not conserved
- To determine whether a collision is elastic or inelastic, you must calculate the kinetic energy of all the objects before and after the collision

CIRCULAR MOTION

- No tricks here! Circular motion is literally looking at things that travel in a circle
- There are **three types** of circular motion
  - Horizontal circular motion
  - Vertical circular motion
  - Banked tracks
- **Properties of circular motion:**
  - **Centripetal acceleration** – the acceleration is towards the centre of the circle
  - **Centripetal force** – the net force acting on the object that is towards the centre
  - The velocity is tangential to the circular path



Formulae:

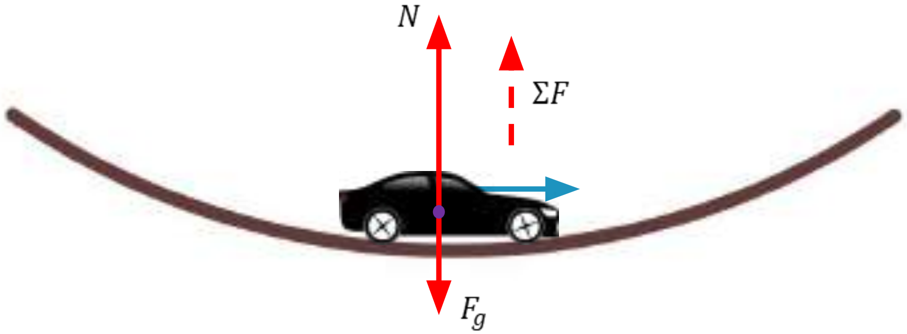
- $a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
- $ma = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2} = \Sigma F$
- T is the period of the object (how long it takes for one revolution to occur)

HORIZONTAL CIRCULAR MOTION

- Circular motion that occurs on a horizontal plane
- **Properties**:
  - The **speed** of the object is **constant**
  - The velocity of the object is always changing
- This is the least complicated type of circular motion

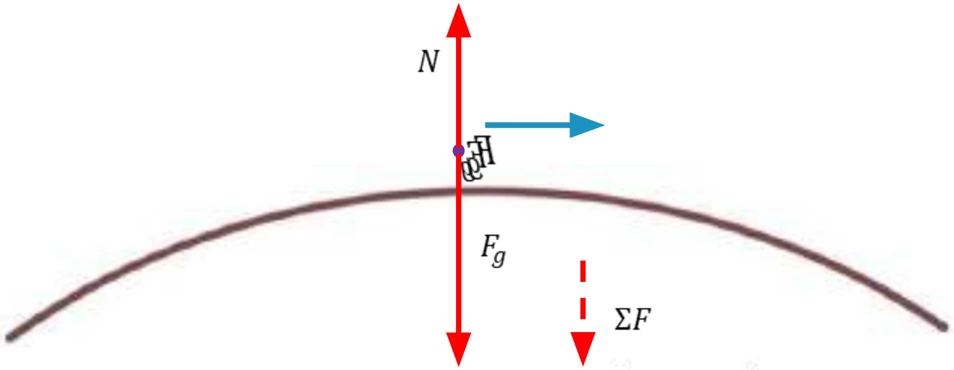
VERTICAL CIRCULAR MOTION

- Circular motion that occurs on a vertical plane
- Speed is not uniform (think energy transformations)
  - Only need to consider the top and bottom of the circle



Bottom of the circle:

- Net force is upwards
- Normal force is greater than the weight force



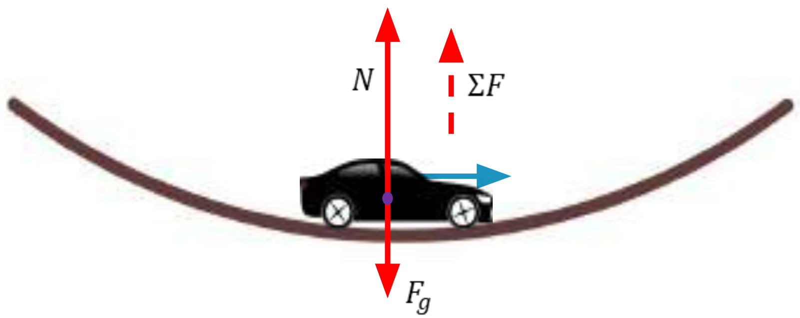
Top of the circle:

- Net force is downwards
- The normal force is smaller than the weight force

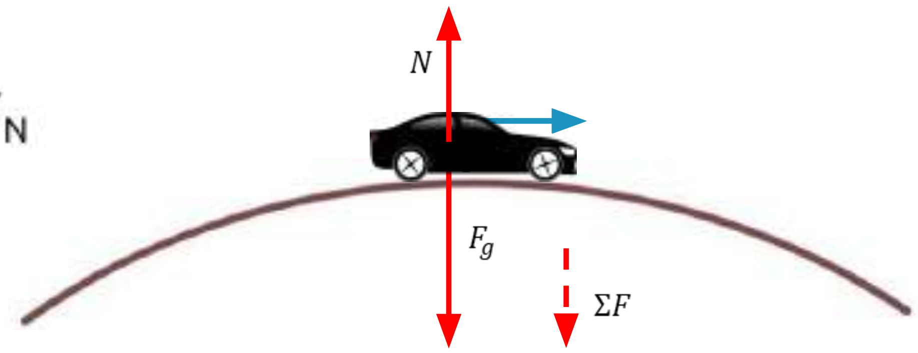
- Formulae: $\Sigma F = ma = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2} = F_N + F_g = F_N + mg$

BE CAREFUL WITH SIGNS!!!

- **Apparent weight** – describes how heavy someone feels
  - This is related to the normal force
  - If $F_N > F_g$, the person feels heavier normal
  - If $F_N < F_g$, the person feels lighter than normal
- **Apparent weightlessness** – occurs when $F_N = 0$ so that the person feels weightless
- **True weightlessness** – occurs when $F_g = 0$ – only occurs in deep space where the gravitational field strength is 0 ($w = mg$)



At the bottom: $F_N > F_g$ hence the person feels heavier than normal



At the top: $F_N < F_g$ hence the person feels lighter than normal

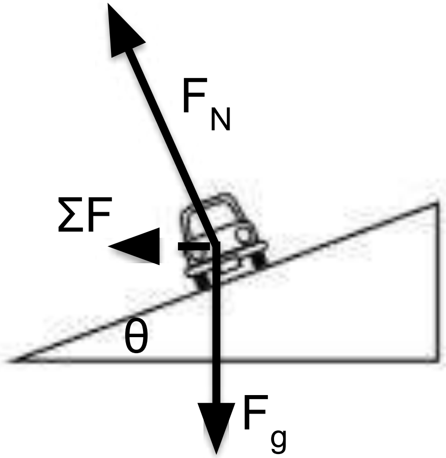
CIRCULAR MOTION BANKED TRACKS

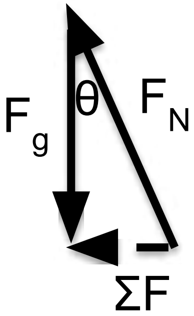
- Circular motion that occurs on an inclined plane – like a velodrome
- In VCE physics, we model this motion at the design speed
- **Design speed** – the speed an object travels at so that friction is not needed to keep it on the track

$$tan\theta = \frac{v^2}{gr}$$

- Note: the **net force** is towards the **centre** and not down the plane (like an inclined plane)
- The triangle of forces can be connected with the circular motion formulae

$\Sigma F = ma = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2}$ to find more information





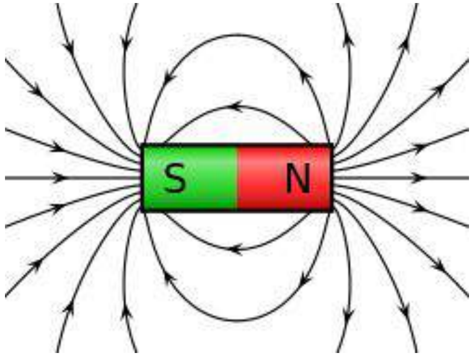
PRACTICE QUESTION

Julia has a mass of 60 kg and is an absolute adrenaline junkie. She loves going to amusement parks – her particular favourite is the Ferris wheel (jks they're so boring). She gets on the Ferris wheel with a radius of 5 m and times the period to be 30 seconds. What is the normal force acting on Julia at the top of the Ferris wheel?

$$\Sigma F = ma = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2}$$

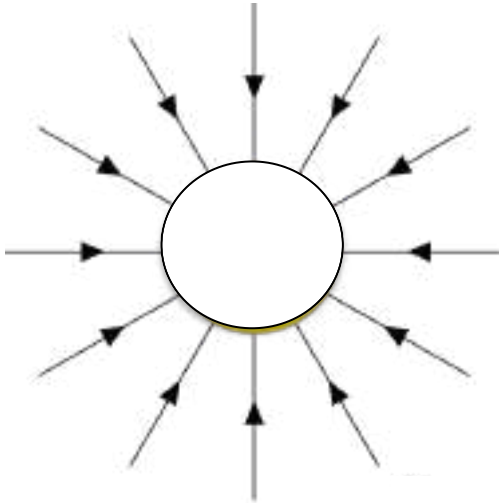
Fields

- **What is a field?**
  - A field is something that alters a region of space
  - When two fields interact, they apply a force on each other
- **How can we represent fields?**
  - **Vectors** – only applies to one point in a region of space
    - Direction of the arrow indicates the direction of the field
    - Length of the line determines the strength of the field
  - **Field lines** – applies to a large region of space
    - The shape of the line shows the shape of the field
    - The closer the lines are, the stronger the field is
    - Note that the lines can never touch



GRAVITATIONAL FIELDS

- A field that is created due to mass
- When two gravitational fields interact, there is an attractive force between the two masses
- **Properties:**
  - They are only attractive
  - Monopole – has one pole
  - The shape is radial
  - Arrows point inwards
  - The field is strongest near the mass



- **Formulae:**
  - $g = \frac{GM}{r^2}$
  - $F_g = \frac{GMm}{r^2}$

g = gravitational field strength (N kg^{-1})
G = gravitational constant = 6.67×10^{-11} N m^2 kg^{-2}
M = mass of the object being orbited (kg)
m = mass of the object doing the orbiting (kg)
r = radius of the orbit (m) – must be measured from the centre of each object
F_g = gravitational force (N)

SATELLITE MOTION

- Looking at satellites/other objects orbiting planets
- This is an example of circular motion
- The **gravitational force** acts as the **centripetal force**
  - This is the only force acting on the satellite
  - The satellite is in **free fall**
  - A person in orbit has no normal force – they experience **apparent weightlessness (not true weightlessness)**

SATELLITE MOTION

- **Formulae:**
  - As the only force is the gravitational force,

$$\Sigma F = ma$$
$$mg = mg$$
$$g = a$$

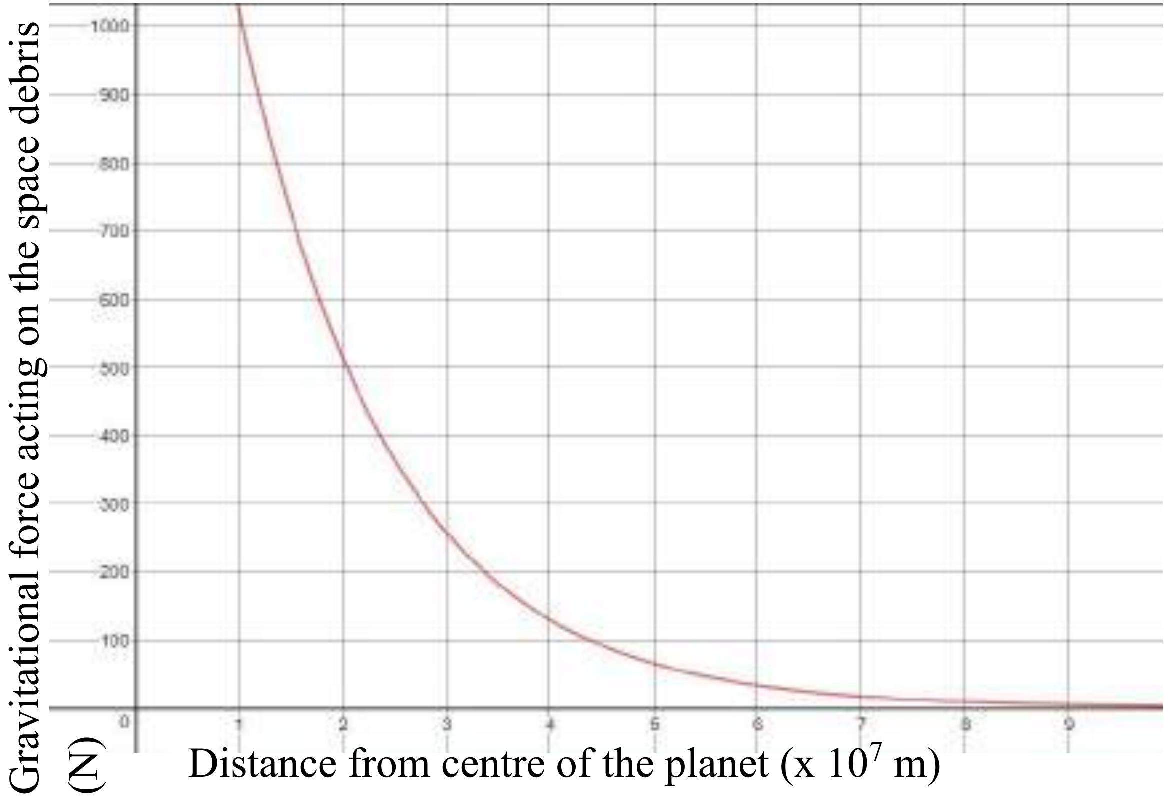
  - Hence,

$$g = \frac{GM}{r^2} = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2} = a$$
$$mg = \frac{GMm}{r^2} = \frac{mv^2}{r} = \frac{4\pi^2 mr}{T^2} = ma = \Sigma F$$

CHANGES IN SATELLITE ENERGY

- There are <u>two types of energy</u> associated with an object in orbit
  - Gravitational potential energy
  - Kinetic energy
- These amounts change when the radius of the orbit changes (changes in height above the surface of the planet)
- Normally, we would use $U_g = mgh$ to find the change in gravitational potential energy as height changes
  - However, we cannot use this in satellite motion as this formula implies that g is constant – this is not true because g decreases as we move further away from the planet
- Instead, we use the area under a force-distance graph to find the change in energy

CHANGES IN SATELLITE ENERGY



Force-distance graph

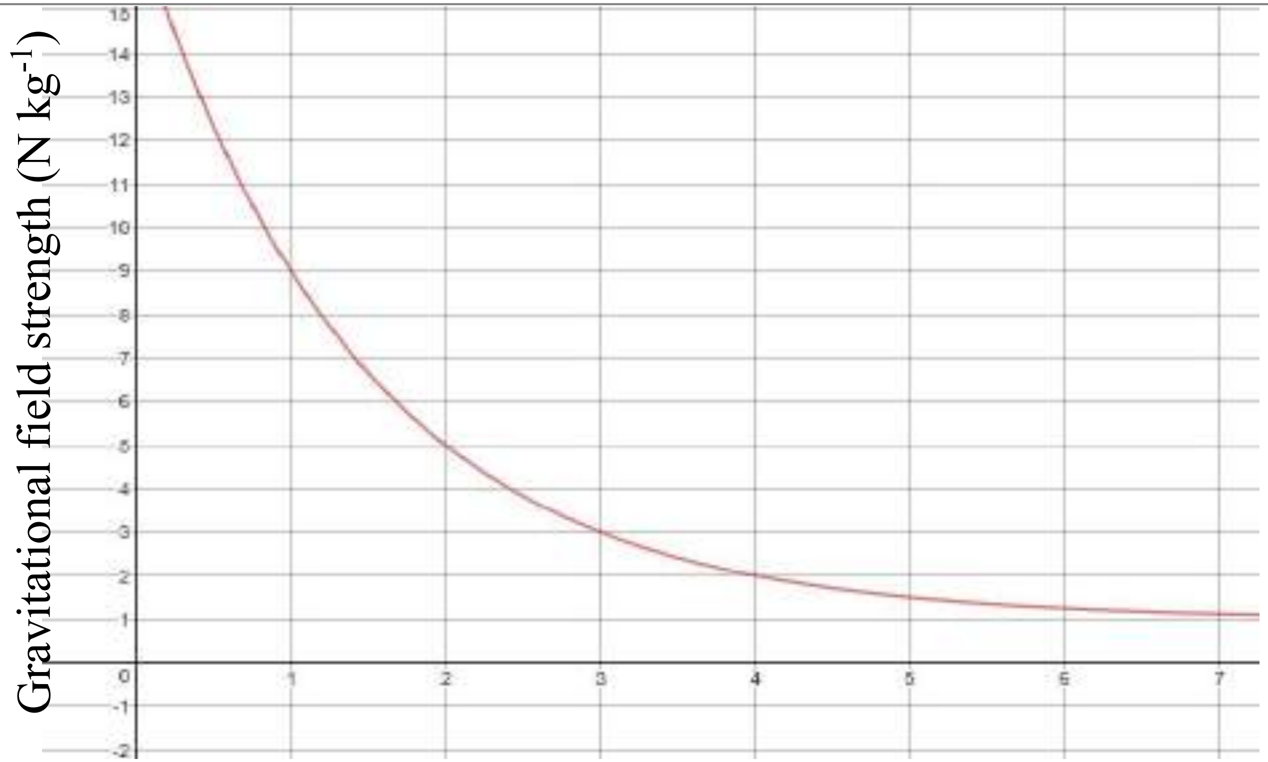
- Use the area under the graph to find the change in energy – for both U_g and E_k
- Increase in height will result in an increase in U_g and a decrease in E_k and vice versa

Change in U_g/E_k for changing the distance from 2 x 10^7 m to 5 x 10^7 m

$$\Delta U_g = area\ under\ the\ graph$$
$$(\Delta U_g = no. of\ squares\ \times area\ of\ one\ square)$$
$$\Delta U_g = 7 \times (1 \times 10^7 \times 100) = 7 \times 10^9 J$$

Hence, there is an increase in gravitational energy by 7 x 10^9 J and a decrease in kinetic energy by 7 x 10^9 J

CHANGES IN SATELLITE ENERGY



Change in U_g/E_k for changing the distance from 4 x 10^{7} m to 1 x 10^{7} m with a mass of 60 kg

$$\Delta U_g = -area\ under\ the\ graph \times mass$$

$$(\Delta U_g = -no.\ of\ squares\ \times area\ of\ one\ square \times mass)$$

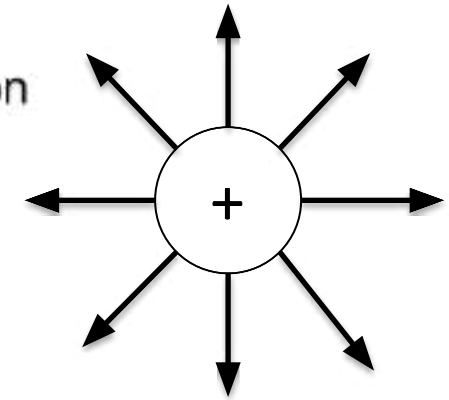
$$\Delta U_g = -13 \times (1 \times 10^7 \times 1) \times 60 = -7.8 \times 10^9 J$$

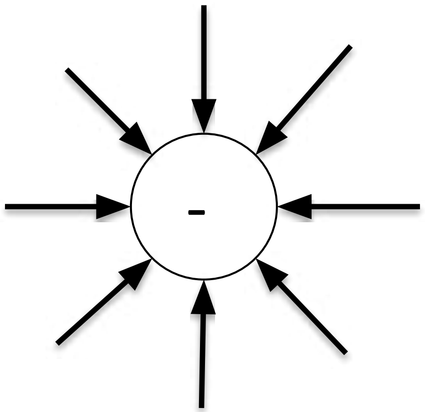
Field strength-distance graph

- Use the area under the graph x mass of the object to find the change in energy – for both U_g and E_k

Hence, there is an decrease in gravitational energy by 7.8 x 10^{9} J and an increase in kinetic energy by 7.8 x 10^{9} J

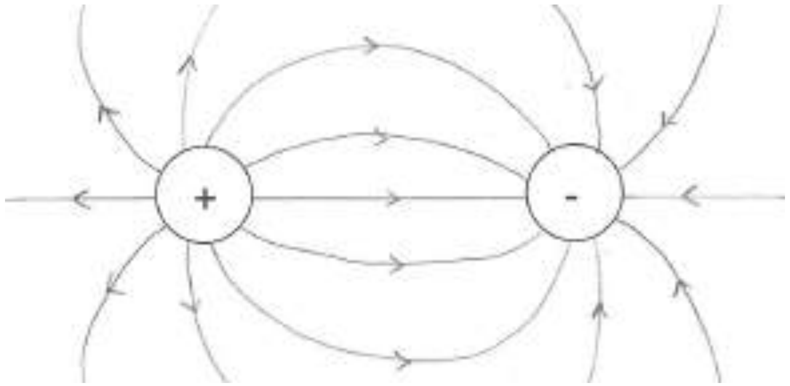
- A field created by an electric charge
- **Point charge** – a charge created by a single point eg. proton, electron
  - **Properties:**
    - Radial
    - Field is stronger closer to the point charge
    - Monopoles
    - Arrows point away for a positive charge
    - Arrows point inwards for a negative charge
- **Formulae**
  - $E = \frac{kq}{R^2}$
    - E = strength of electric field ($N\ C^{-1}$)
    - k = Coulomb constant = $8.99 \times 10^9\ N\ m^2\ C^{-2}$
    - q = charge of the point charge (C)
    - R = distance from the charge (m)





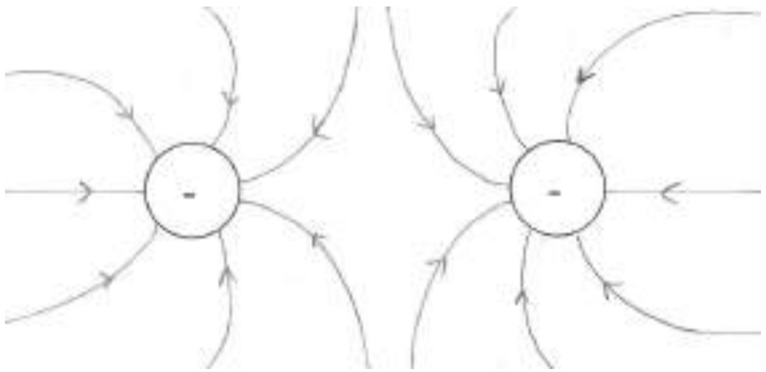
INTERACTION OF ELECTRIC FIELDS

- Opposite charged particles create an attractive force on each other
- Like charged particles create a repulsive force against each other



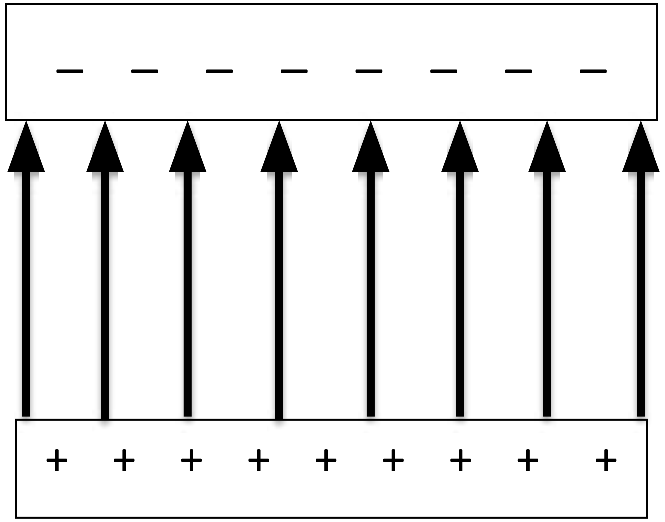
Formulae:

- $F = \frac{kq_1q_2}{R^2}$
  - F = force on each charge (N)
  - k = Coulomb constant = 8.99 x 10^9 N m^2 C^{-2}
  - q_1 = charge of the 1^{st} point charge (C)
  - q_2 = charge of the 2^{nd} point charge (C)
  - R = distance between the centres of the two charges (m)



EXTERNAL ELECTRIC FIELDS

- Two oppositely charged plates create a uniform electric field – this is a **dipole**
  - Indicated by the evenly spaced parallel lines
- Putting a charged particle (eg. an electron) in the field will cause it to move towards the oppositely charged plate – hence work is done on the particle
- **Formulae:**
  - $E = \frac{V}{d}$
  - $F = qE$
  - $W = qV$
    - E = strength of the external electric field (V m^{-1})
    - V = voltage (V)
    - d = distance between the plates (m)
    - F = force (N)
    - q = charge of the point charge (C)
    - W = work (J)



PRACTICE QUESTION

An electron is placed between two electric plates which are placed 30 cm apart and have a potential difference of 20 V. What is the force acting on the electron?

Data: charge on an electron = 1.6×10^{-19} C

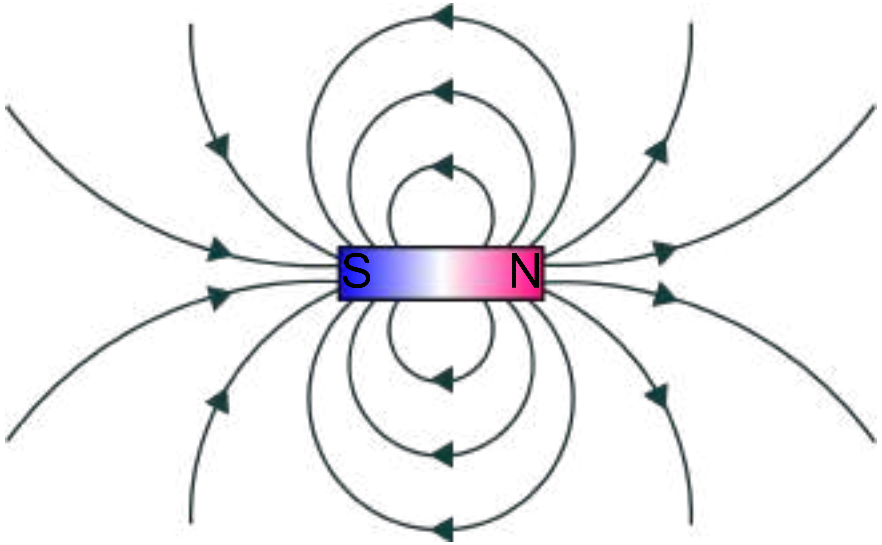
$$E = \frac{V}{d}$$

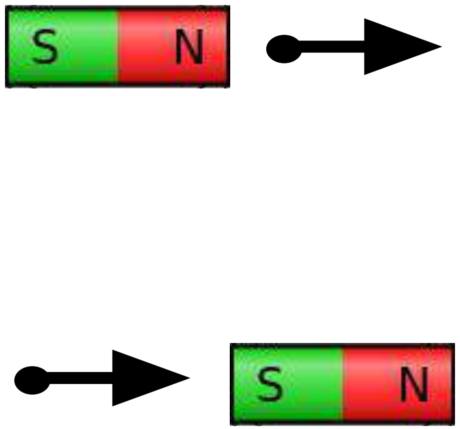
$$F = qE$$

$$W = qV$$

MAGNETIC FIELDS

- A field created by magnetism
- Magnets are always dipoles
- The arrows point away from the north pole and towards the south pole





Two identical bar magnets of the same strength are arranged at right angles and are equidistant from point P, as shown in Figure 1.

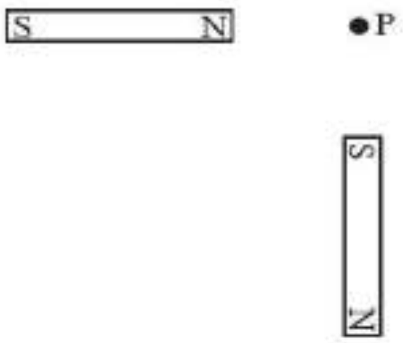


Figure 1

For Question 1 only, ignore Earth's magnetic field.

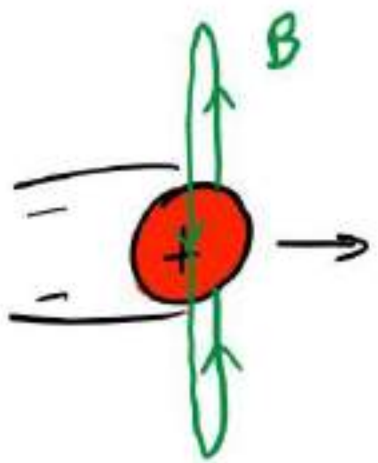
Question 1

At point P on the diagram, draw an arrow indicating the direction of the combined magnetic field of the bar magnets.

1 mark

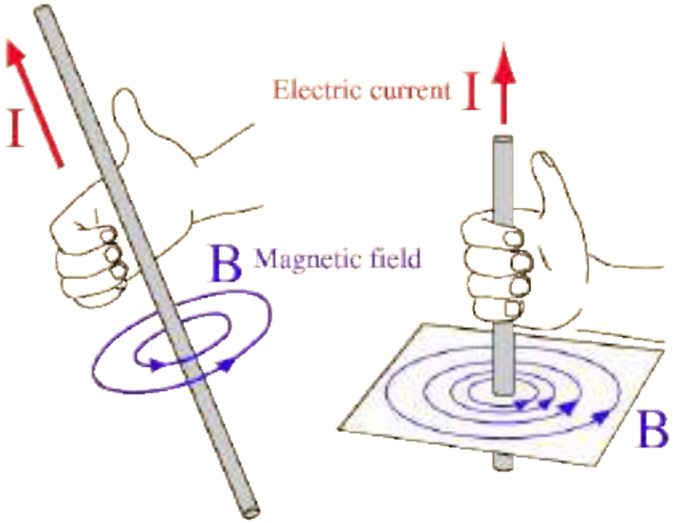
ELECTRIC/MAGNETIC FIELDS

- There is a connection between electric and magnetic fields
- A moving charge will create a magnetic field – it makes a circle around the charge
- Current is the movement of charge – hence a current will create a magnetic field as well



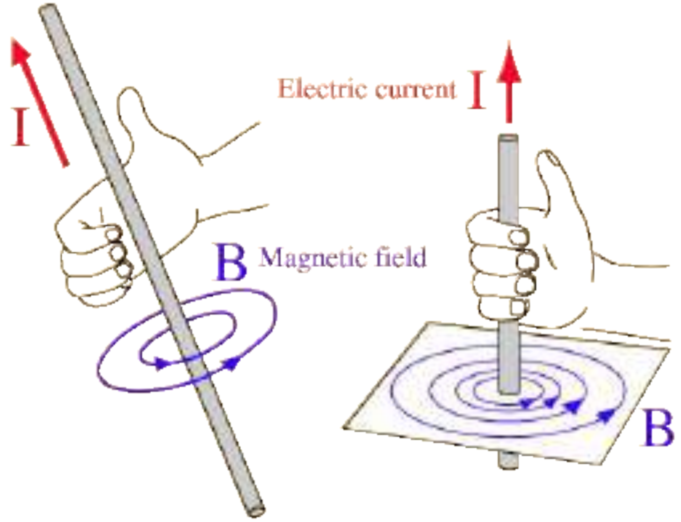
RIGHT HAND GRIP RULE

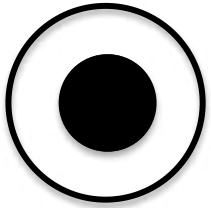
- We can find the direction of the magnetic field based on the direction of the current using the right hand grip rule
- **Thumb** is the direction of the **positive current**
  - If it is a negatively charged particle, point your thumb in the opposite direction the particle is travelling in
    - Eg. an electron moving to the right, means you must point your thumb to the left
- The direction that your **fingers** curl in indicates the direction of the **magnetic field**

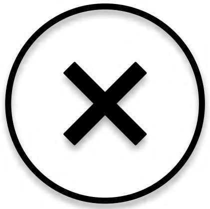


RIGHT HAND GRIP RULE

- The two circles below are wires
  - A **circle** in the wire represents a **current that goes out of the page**
  - A **cross** in the wire represents a **current that goes into the page**
  - This can be remembered by thinking of an arrow
- Use the right hand grip rule to determine whether the magnetic field around these wires is clockwise or anticlockwise around the current



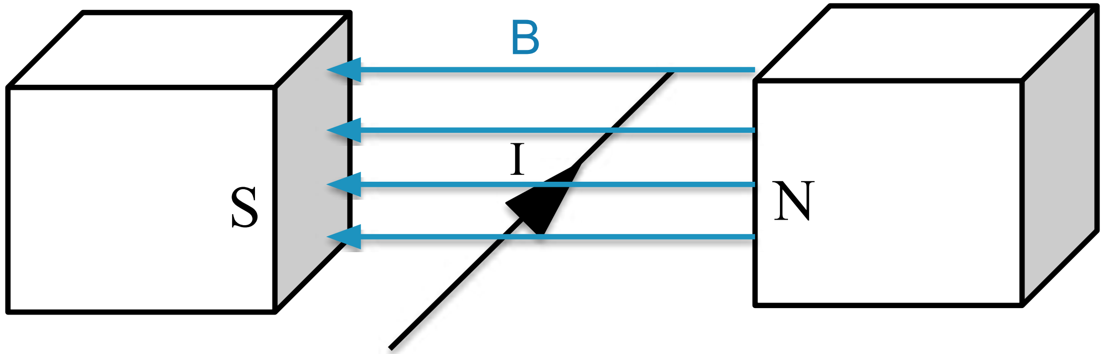




CURRENT IN A MAGNETIC FIELD

- A current creates a magnetic field
- If a current is placed in an external magnetic field, its own magnetic field interacts with the external magnetic field
- When **two fields interact**, they apply a **force** on each other

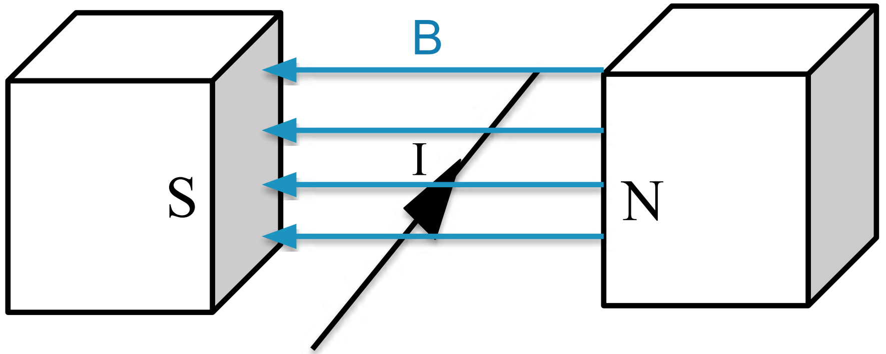
- Consequently, a **current** in a **magnetic field** will have a **force** applied on it
- Note: there is no force acting on the current if it is **parallel** to the magnetic field (you don’t need to know why – it is beyond the scope of the study design)



Fields

RIGHT HAND SLAP RULE

- When a current is placed perpendicular to an external magnetic field, we can use the right hand slap rule to determine the direction of the force acting on the current
- **Thumb** indicates the direction of the **positive current**
- **Fingers** indicate the direction of the **magnetic field** (from north to south)
- **Palm** represents the direction of the **force** on the current (think of the name of the rule to remember this)



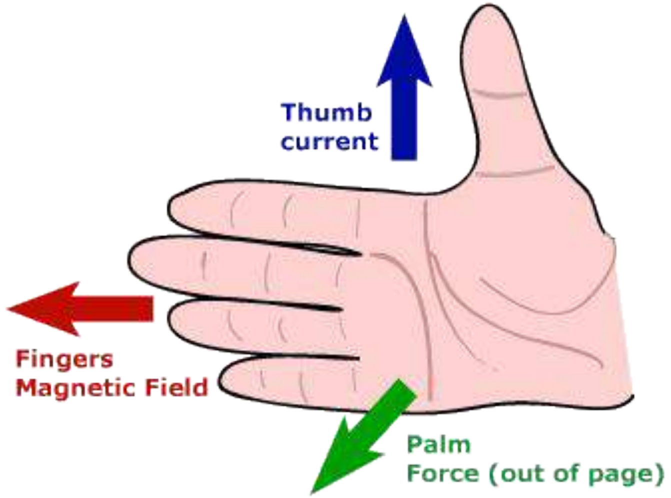


Photo credit: http://physics145spm.blogspot.com/2012/08/force-on-current-carrying-conducto

CURRENT IN A MAGNETIC FIELD

- The strength of the force acting on a current perpendicular to the magnetic field can also be calculated using

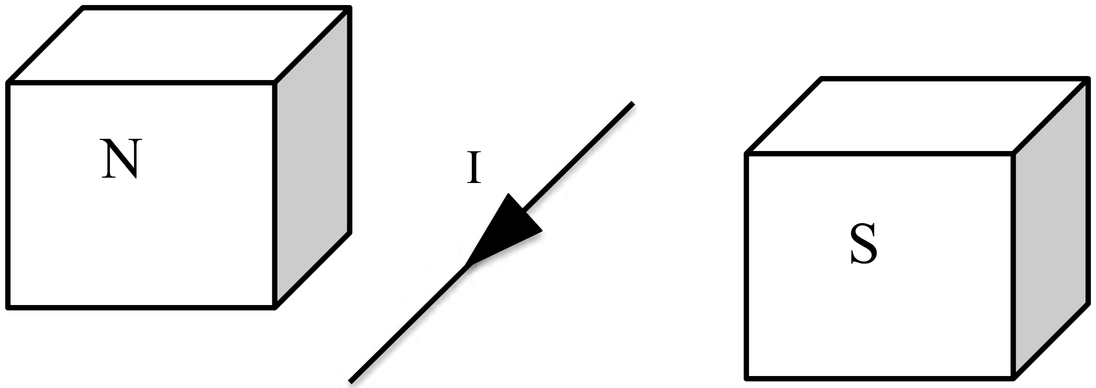
$$F = nBIl$$

- Where:
  - F = force (N)
  - n = number of turns (which means number of wires/loops)
  - B = magnetic field strength (T – Tesla)
  - I = current (A)
  - l = length of the wire in the magnetic field (m)

PRACTICE QUESTION

A 30 cm piece of wire is in a magnetic field of 0.2 T. There is a current of 2 A running through the piece of wire that is going out of the page. What is the direction and magnitude of the force acting on the wire?

$$F = nBIl$$



Remember that the magnetic field lines go from north to south

CHARGED PARTICLE IN A MAGNETIC FIELD

- A moving charged particle will have a magnetic field
- When you put a **charged particle** in an **external magnetic field**, its magnetic field will interact with the external magnetic field to create a **force**
- We can use the **right hand slap** rule to determine the direction
  - The **velocity** of the particle acts as the direction of the **current** (note this must be positive)
  - Note that the force acting on the particle is always **perpendicular** to the velocity
    - This creates **circular motion** – the force from the two fields acts as the **centripetal force**

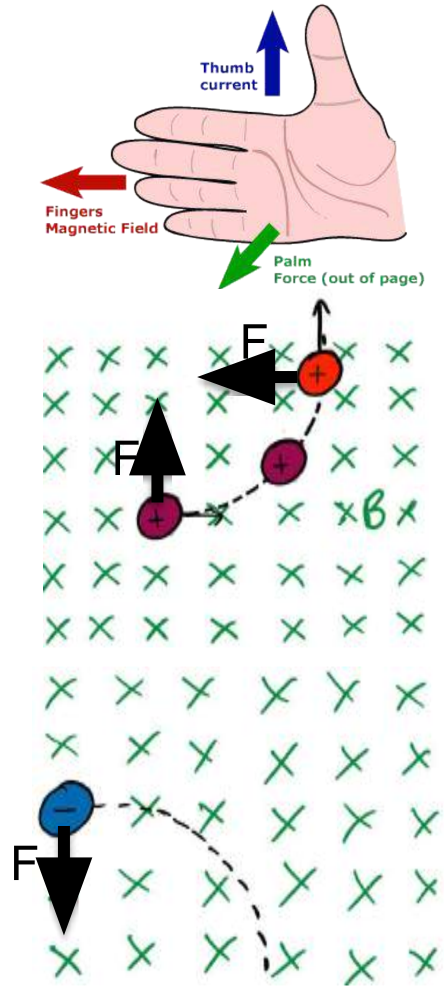
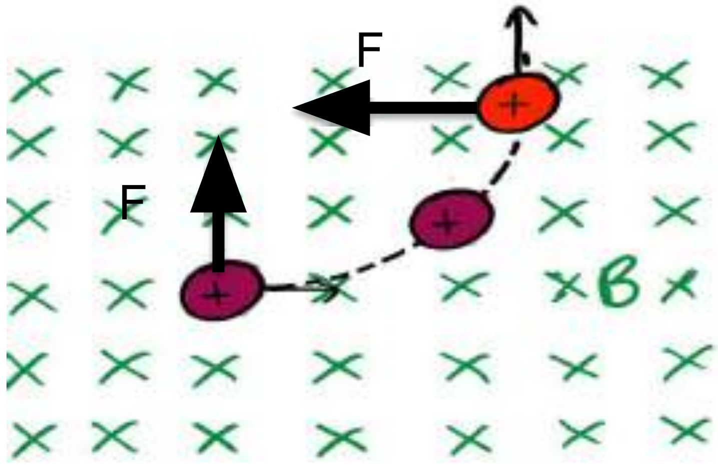


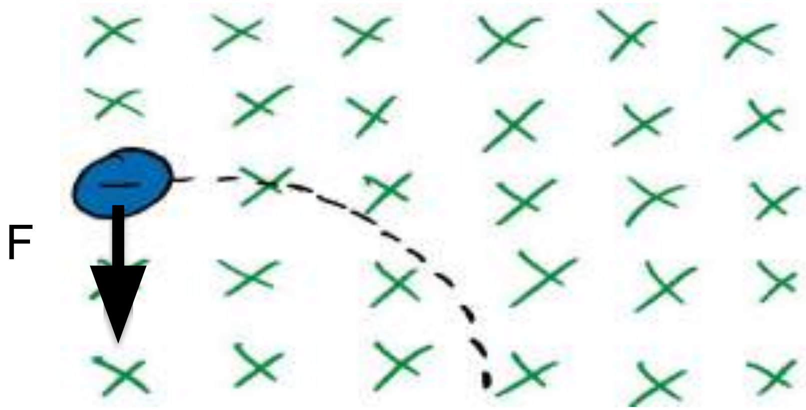
Photo credit: http://physics145spm.blogspot.com/2012/08/force-on-current-carrying-conducto

CHARGED PARTICLE IN A MAGNETIC FIELD

Formulae:

- $F = qvB$
    - F – force (N)
    - q – charge (C)
    - v – velocity (m s^{-1})
    - B – magnetic field strength (T)
- $r = \frac{mv}{qB}$
    - r – radius (m)
    - m – mass (kg)
    - v – velocity (m s^{-1})
    - q – charge (C)
    - B – magnetic field strength (T)





Fields

TWO PARALLEL WIRES

- Two wires that are parallel to each other will exert a force on each other due to the interaction of their magnetic fields
- How do we know whether or not this force is attractive or repulsive?
    - Use the right hand grip rule and right hand slap rule!

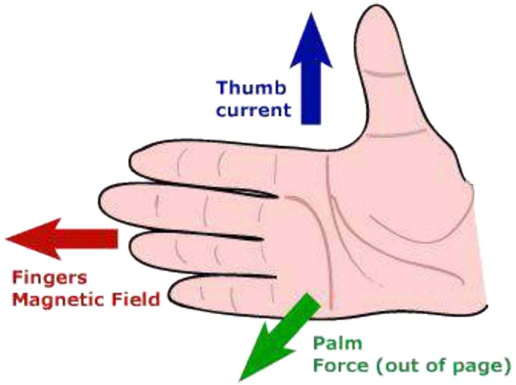
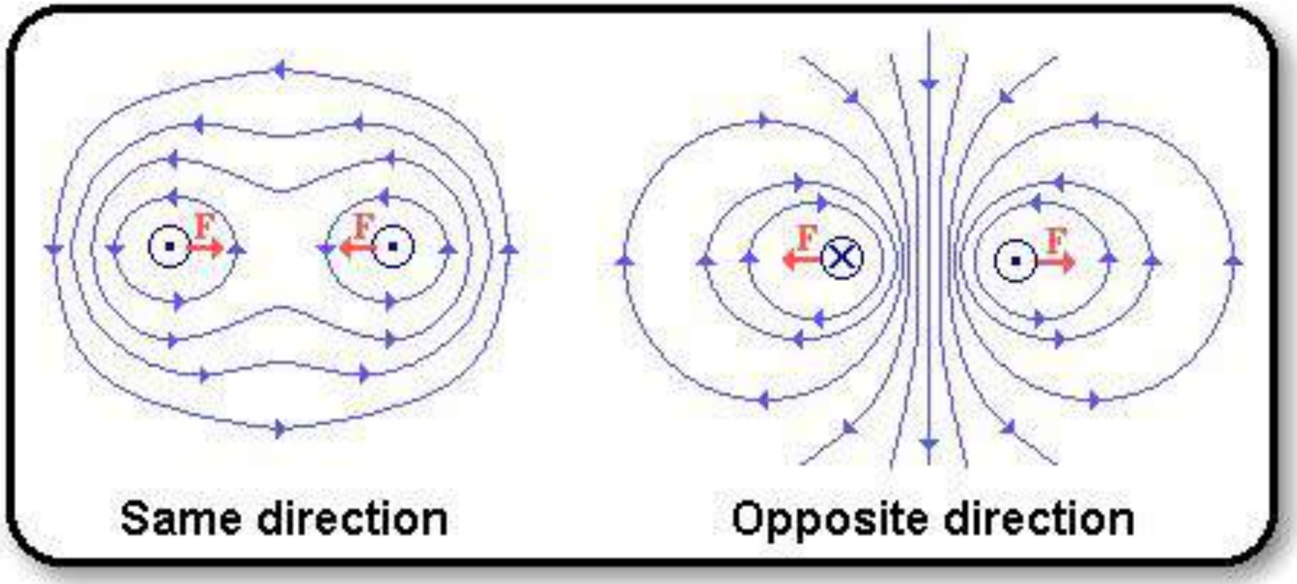


Photo credit: http://physics145spm.blogspot.com/2012/08/force-on-current-carrying-conducto

TWO PARALLEL WIRES

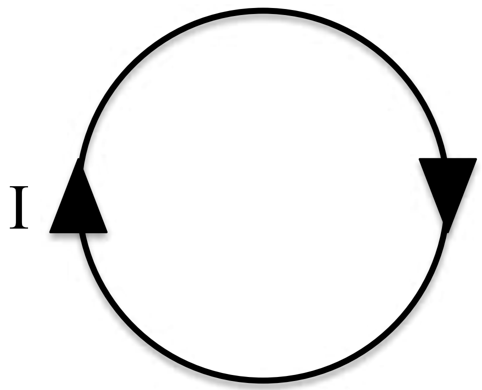


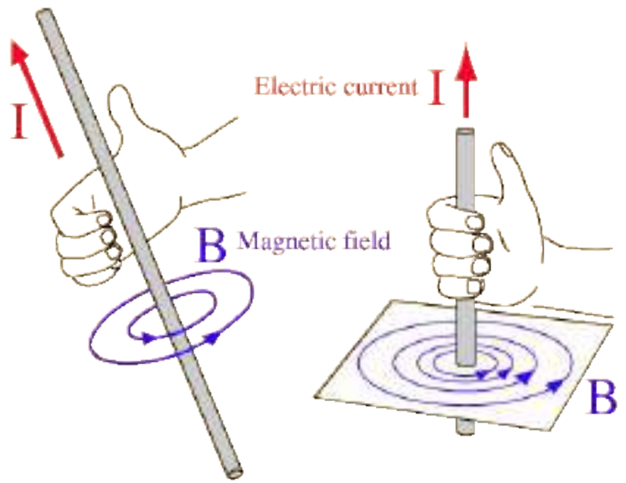
If the current is in the **same direction**, they **attract** each other
If the current in the **opposite direction**, they **repel** each other

Photo credits: http://www.physics.louisville.edu/cldavis/phys111/notes/magn_forces_parr.html

WIRE LOOPS

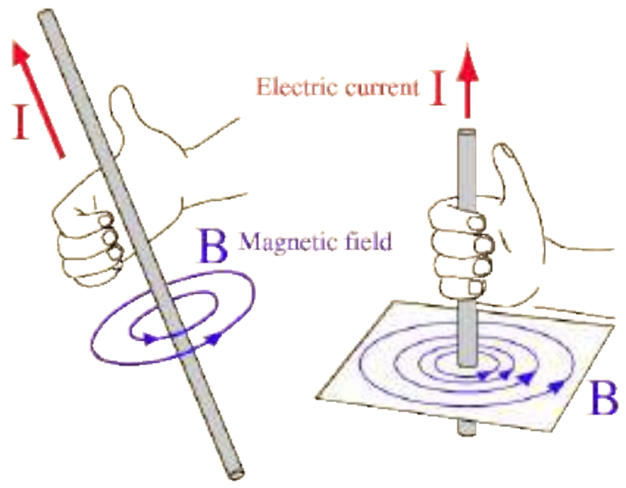
- When looking at a current in a loop, we are also interested in the direction of the magnetic field
- Use the **right hand grip rule** to determine the direction of the magnetic field inside and outside the loop
  - Use crosses to indicate the magnetic field going into the page and dots to indicate the magnetic field going out of the page (same notation we used for current)

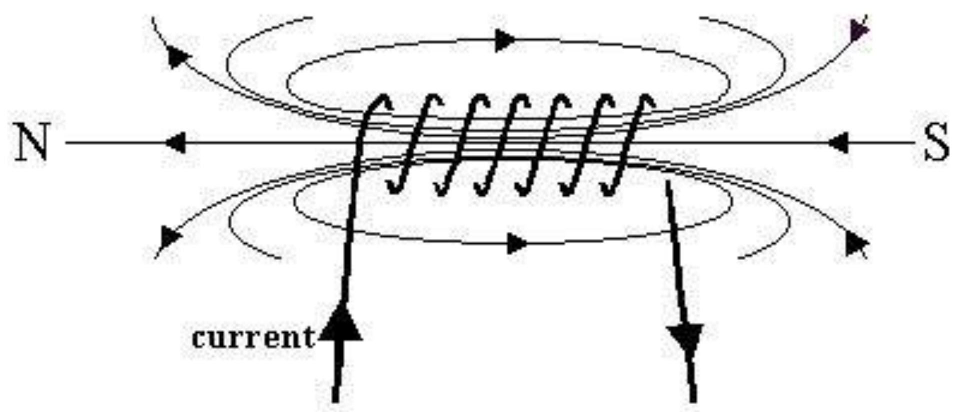


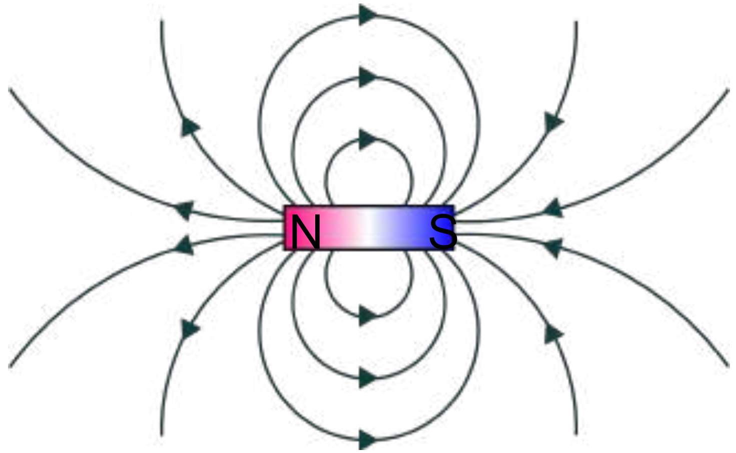


SOLENOIDS

- **Solenoids** are just a wire bent such that it looks like a bunch of loops of wires put together
- A solenoid acts as a **bar magnet**
  - There is a north and south end of the solenoid
  - We can prove the direction of these field lines using the right hand grip rule
- Note: when drawing field lines for a solenoid, ensure that your lines go through the solenoid and do not touch







REVERSE RIGHT HAND GRIP RULE

- Another way of finding the north and south pole of a solenoid is by using the **reverse right hand grip rule**
  - Instead of the **thumb** being the direction of the current, it points to the **north pole**
  - Instead of the **fingers** being the direction of the magnetic field lines, it is the direction of the **current**

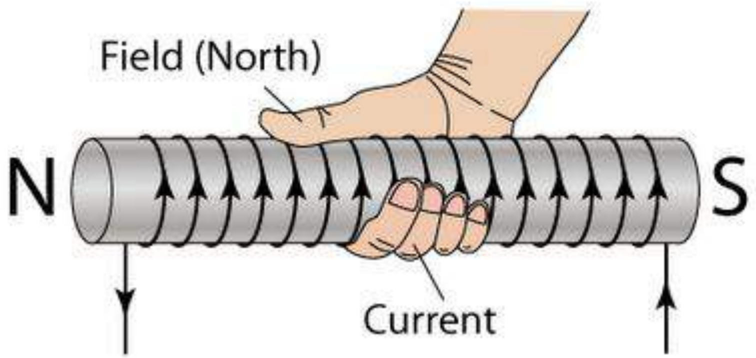


Photo credits: https://www.miniphysics.com/ss-magnetic-field-due-to-c

DC MOTORS

- A **motor** is a device that converts electrical energy into kinetic energy using current and an external magnetic field

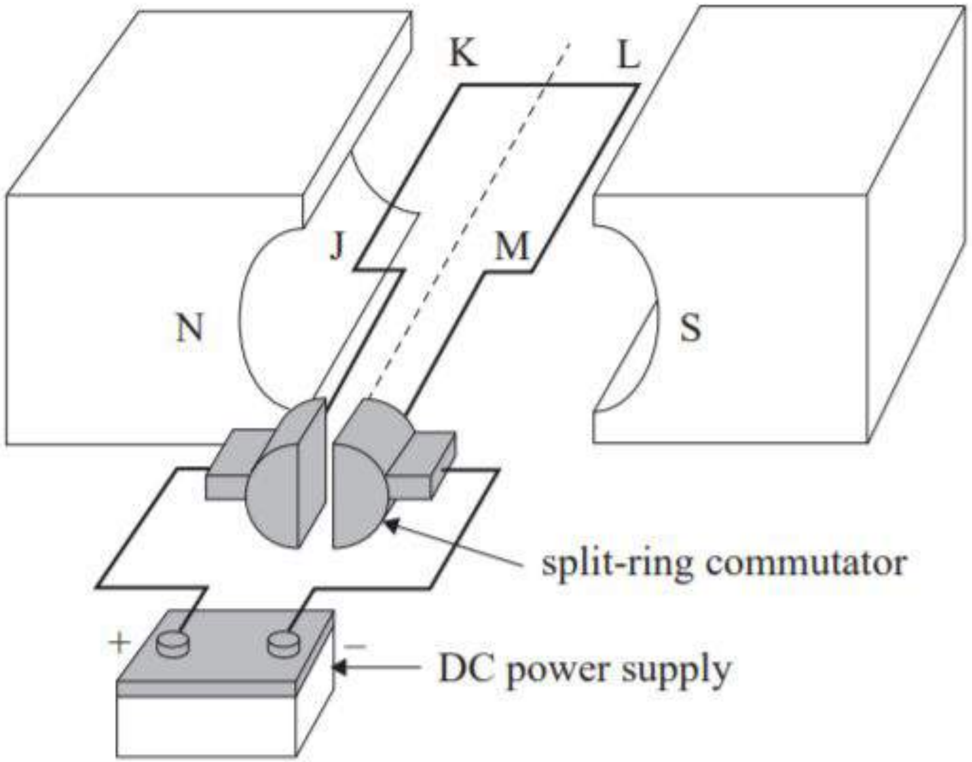
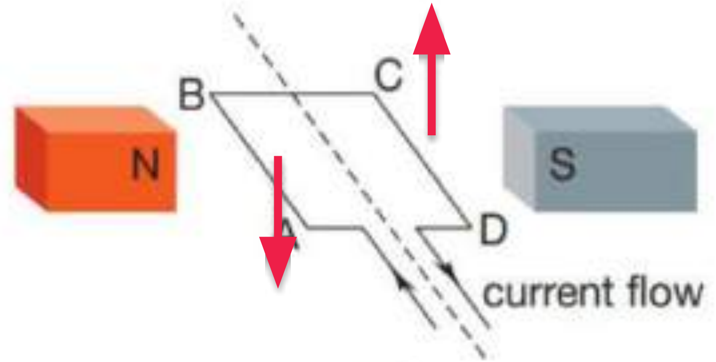
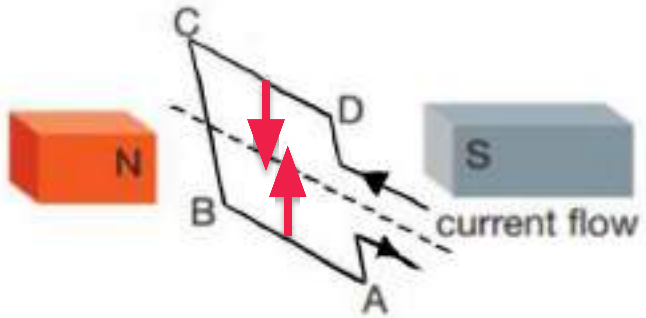
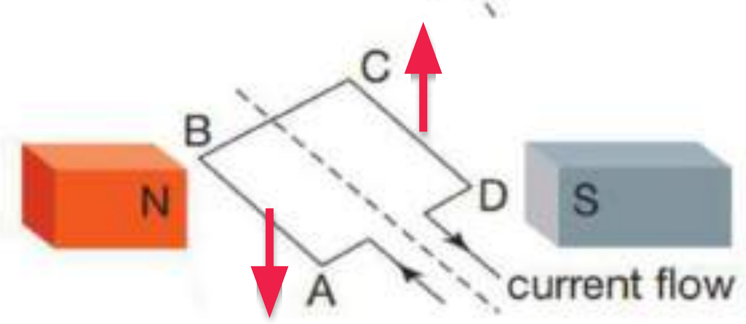


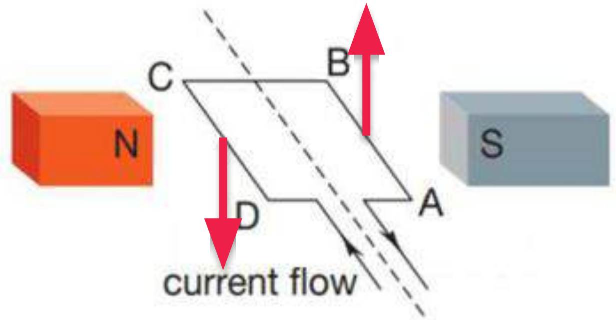
Photo credits: https://www.vcaa.vic.edu.au/Documents/exams/physics/2017/2017physics-w.pdf

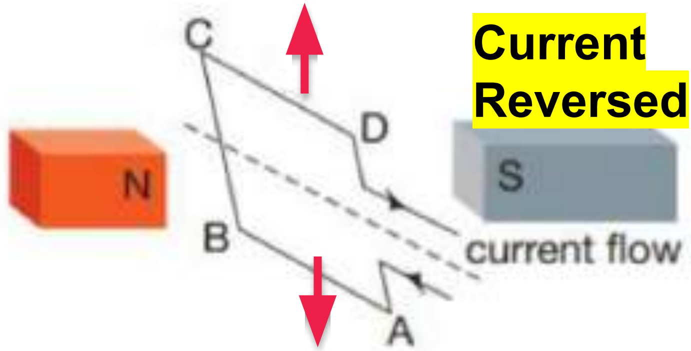
DC MOTORS



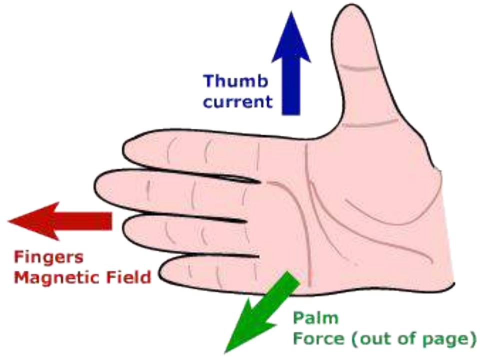






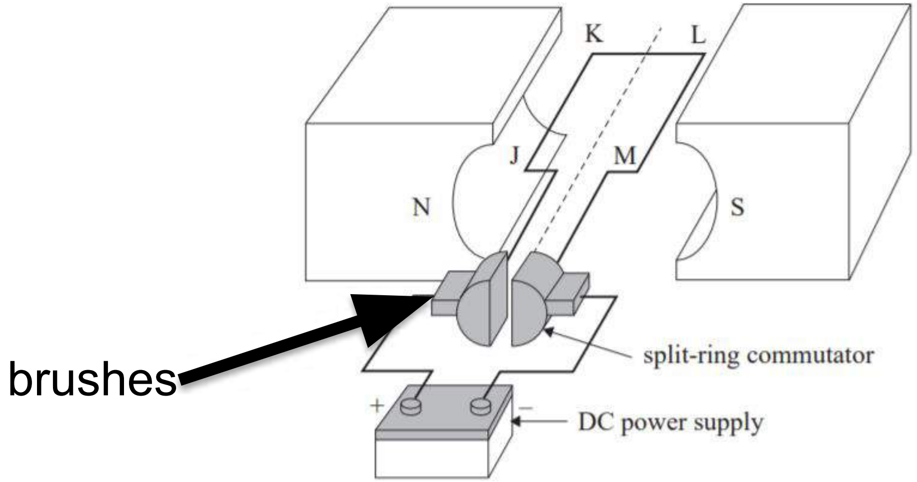


Current Reversed



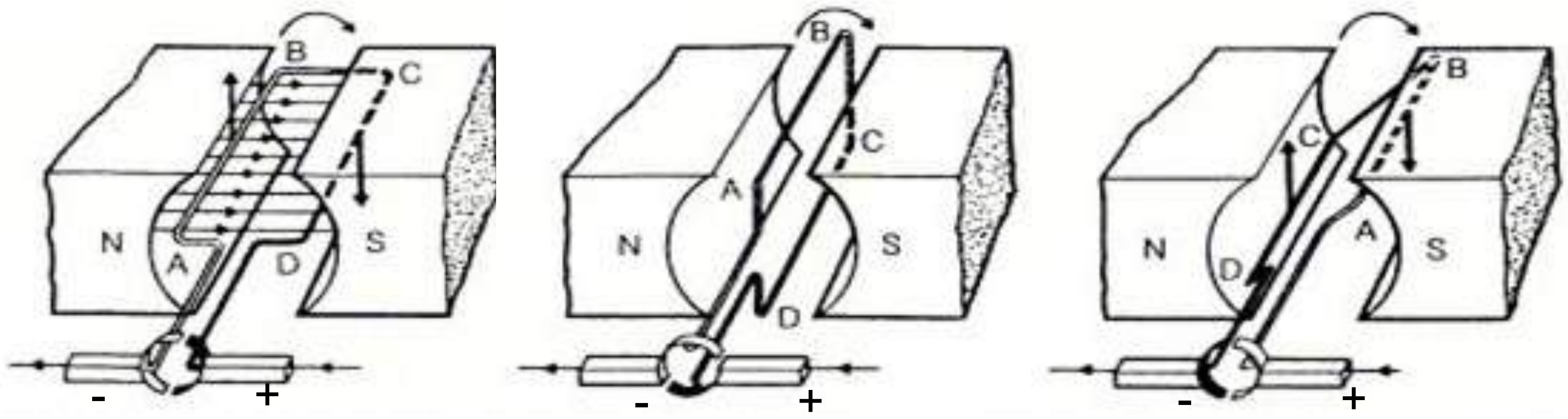
SPLIT RING COMMUTATORS

- The **current** needs to be reversed **every half cycle** in a DC motor to keep it rotating
- A **split ring commutator** completes this function
  - A split ring commutator is a cylinder with a split in the middle
  - The cylindrical bit is connected to the coil
  - The rectangular bit is called the brushes and are connected to the terminals of the power supply



SPLIT RING COMMUTATORS

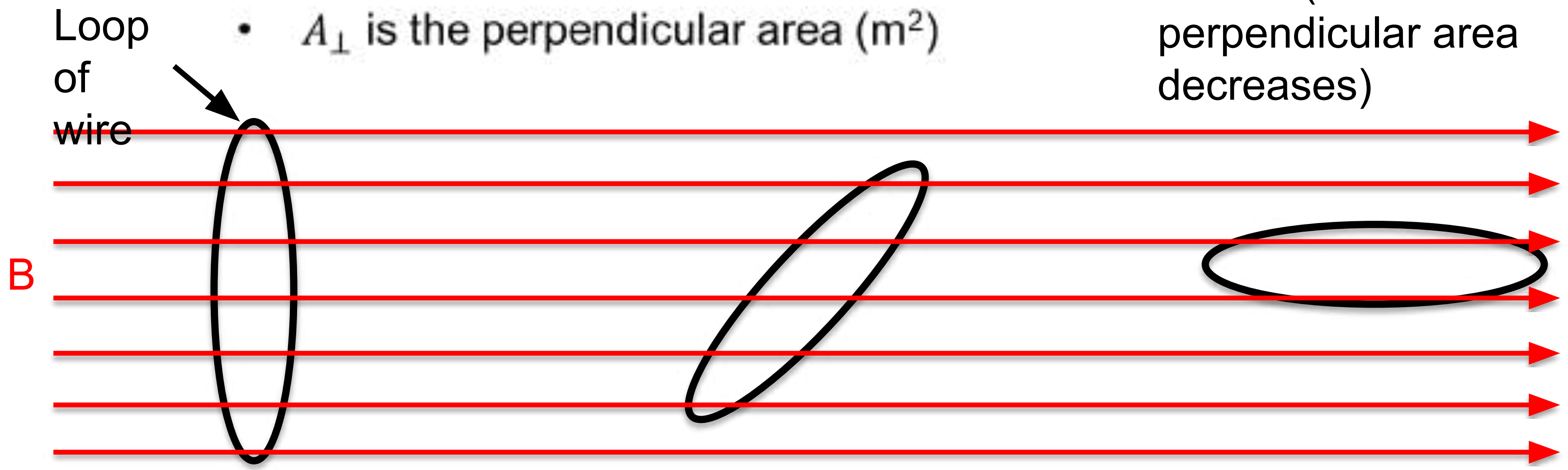
- How does the split ring commutator work?
  - Initially the current flows from D to C – causing the coil to turn clockwise
  - When a **vertical position** is reached, the gaps in the split ring commutator align with the brushes **no current** flows through the coil but the coil **continues to turn** from previous movement
  - The side of the ring that was initially in contact with the positive terminal is now in contact with the negative terminal and vice versa, **changing the direction of the current**
    - The current now flows from C to D



FLUX

- **Flux** is defined as the number of magnetic field lines passing through an area of a wire
- **Mathematically:**
  - $\Phi_B = BA_\perp$
    - Φ_B is the flux (Webers – Wb)
    - B is the magnetic field strength (T)
    - $A_\perp$ is the perpendicular area (m^2)

Note that the flux decreases as the coil rotates (ie. The perpendicular area decreases)



Perpendicular to field lines (flux is max.)

45º angle (less field lines pass through)

Parallel to field lines (flux is 0)

FARADAY'S LAW

- **Faraday's Law** states that if there is a change in flux, emf will be induced in the coil of wire
- Faraday's law as an equation is given by:

$$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$$

- Where
  - ε is the electromotive force (V)
  - N is the number of turns (number of loops)
  - $\Delta\Phi_B$ the change in magnetic flux (Wb)
  - Δt is the time taken for the change of magnetic flux to occur (s)

- **Important note**: A change in flux induces emf, NOT current. Current is only induced when emf is induced in a closed circuit

PRACTICE QUESTION

A coil is turned from the vertical position shown to a horizontal position in 0.4 seconds. The coil has an area of 0.8 m^2 and the strength of the magnetic field if 1.2 T. What is the average emf generated in the coil?

$$\Phi_B = BA_\perp$$

$$\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$$

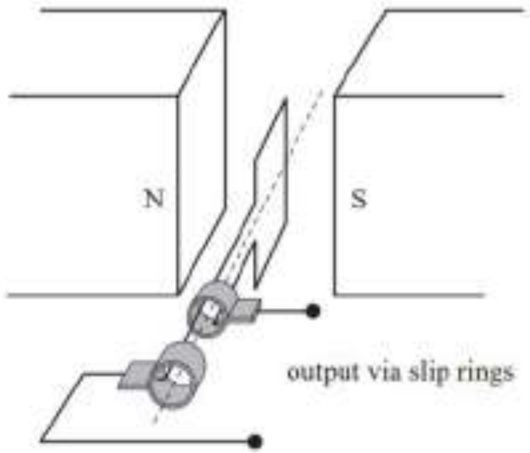
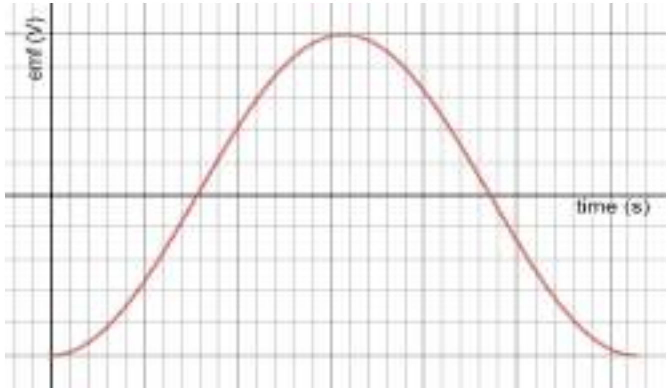


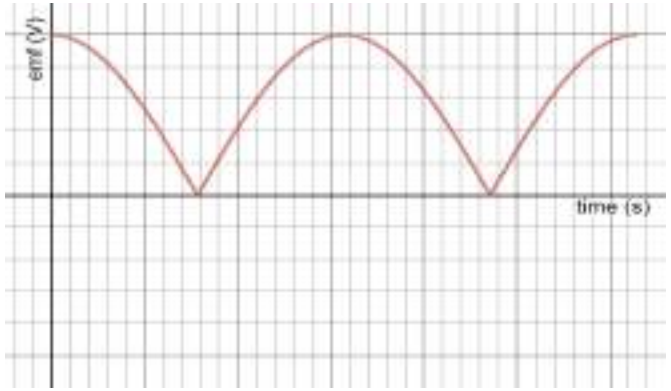
Photo credits: https://www.vcaa.vic.edu.au/Documents/exams/physics/2017/2017physics-w.pdf

SLIP RINGS VS. SPLIT RING COMMUTATORS

- Slip rings create an AC output
- If a split ring commutator was to be used, a DC output would be created
  - Every time the emf changes direction, each side of the split ring commutator changes the terminal it is in contact with – they cancel each other out to create a DC voltage



Slip-ring emf output



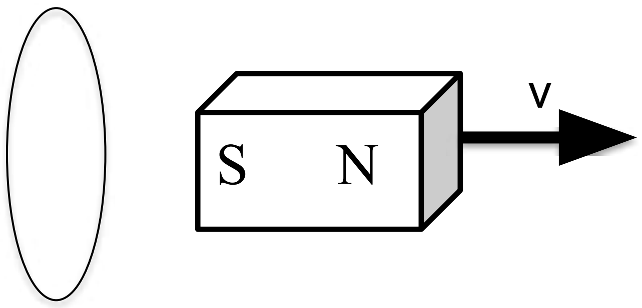
Split-ring commutator emf output

LENZ'S LAW

- This concept flat out took me 2 weeks to understand so please don't freak out
- **The actual definition of Lenz's Law:**
  - "any induced current in a loop will be in the direction so that the flux it creates will oppose the change in the flux that produced it"
- **Breaking down this definition:**
  - Lenz's law is used to determine the direction of the current created when there is a change in flux induces emf induces current
  - The aim of the current is to create a flux that opposes the flux that induced it

LENZ'S LAW

- Using Lenz's Law:
  1. <u>**Describing the initial change in flux**</u>
     - Must include a **direction** and whether the flux is **increasing/decreasing**
     - Eg. direction is based on magnetic field lines (**right**)
       the magnet is moving further away so the flux is decreasing as B is **decreasing** ($\Phi_B = BA_\perp$)
     - Hence the change in flux is to the **right** and **decreasing**

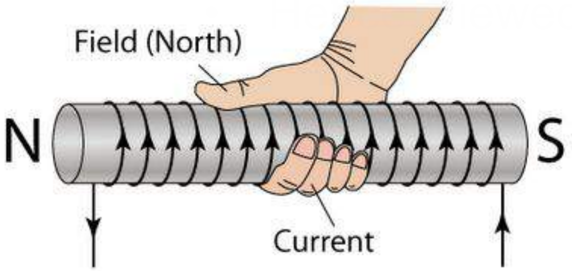


  2. <u>**Figuring out the opposing flux created by the current**</u>
     - An opposing flux will be changing **ONE OF the direction or increasing/decreasing**
     - Eg. the opposing flux can either be to the **left** and **decreasing** OR to the **right** and **increasing**
       - To make life easier, try to ensure that the **opposing flux** uses the word **increasing** – this is important for the 3rd step

3. **Figuring out the direction of the current from the opposing flux**

- This is the reason having "increasing" in the opposing flux is important
- We use the **(reverse) right hand grip** rule to determine the **direction of the current**
  - Eg. The opposing flux is to the **right** and **increasing** (step 2), using the reverse right hand grip rule, our thumb points to the right
    - If we used left and decreasing, our thumb still points to the right and it gets confusing

from the magnet, the current is anticlockwise



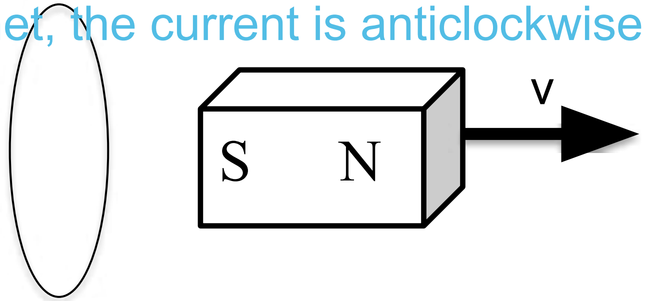


Photo credits: https://www.miniphysics.com/ss-magnetic-field-due-to-c

TIPS FOR YEAR 12

- Print out the **study design** – this is your exam in dot point form
  - Check off things as you do them in class
- Make sure you have an **organised system for your notes** early in the year
- Be **organised** and manage your **time** – this will help reduce stress
  - This might include making a timetable, making a list, estimating how long things will take and when you do them etc.
  - Be **realistic** about the work you take on from day to day
  - Take **scheduled breaks** – this can help with reducing procrastination
- Start **planning out your year** and know when your SACs will be
  - You may like to be aware of your SACs two weeks in advance
  - E.g. prepare notes in the first week and do practice questions in the second week
- **Revise regularly** throughout the year
- **Keep perspective** – VCE is about furthering your education into tertiary studies or into a job – you can always pathway into your dream if needed

TIPS FOR PHYSICS 3/4

- Make sure you know how to use your **scientific calculator**
- Make sure you know the **basic skills** like how to do algebra, rearrange vectors etc.
- Make sure you understand the **concepts along with the formulae**
- Print out the **formula sheet** and use it in class so you know where all the formulae are
- Make note of what things you want on your **cheat sheet** throughout the year – particularly any **derived formulae** or **concepts** you don't fully understand
- Make your **cheat sheet** well before the exam so you can practice using it during practice exams
- Do heaps of **practice questions**!!! Especially before SACs
    - Many people struggle with the worded questions in particular – practice these early on!!!